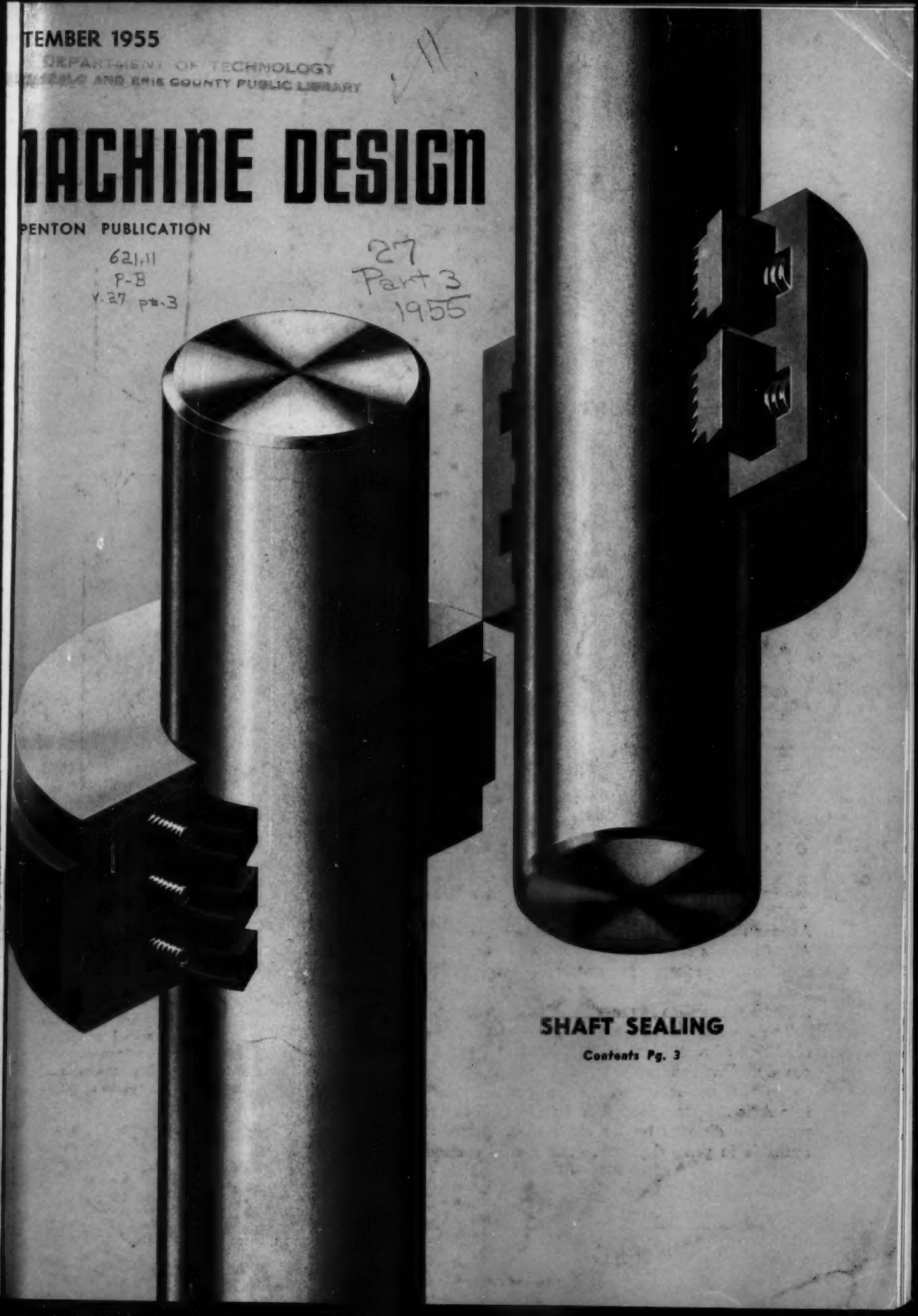
TEMBER 1955

MACHINE DESIGN

PENTON PUBLICATION



SHAFT SEALING

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As manufacturers of *diversified* industrial equipment, Allis-Chalmers has been called upon to solve control application problems in practically every industry. This specialized experience in coordinating power utilization is *yours* when you specify Allis-Chalmers control.

The Allis-Chalmers line includes control for every condition of motor operation. Functions include full or reduced-voltage starting, acceleration, speed control, reversing or non-reversing, and dynamic braking. Built into Allis-Chalmers control is the type and degree of protection dictated by the application. Controls are available in general-purpose and special enclosures.

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● For help on a specific control application, call your Allis-Chalmers representative. His recommendations are backed by Allis-Chalmers engineering departments . . . by experience gained in solving thousands of control problems . . . by complete research and testing facilities.

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

SEPTEMBER 1955
Vol. 27—No. 9

REGULAR DEPARTMENTS

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of editorial articles 209

ADDITIONAL DATA
on new products and methods 225

Contemporary Design

Over the Board

Design—An Intelligence Problem

One of the Hoover Commission task forces has been studying various security agencies in the government. As a by-product of their activity, they came up with a very neat, concise definition of "intelligence":

> *Intelligence deals with all the things which should be known in advance of initiating a course of action.*

According to this definition, most designers spend a lot of time being intelligence agents. So dust off the false mustache, break out the invisible ink, study up on your secret codes, and let's get going on that preliminary drawing you were supposed to do last week.

The Literary Guild

Engineers do a fair amount of writing. That's one of the conclusions reached by Douglas Washburn of Rensselaer Polytechnic after a study of Westinghouse engineers. Design and development engineers spend between 5 and 20 per cent of their working time writing, and some even spend as much as 30 per cent. Most, however, range from 5 to 10 per cent. What do they write? Well, it's likely to be anything from a letter to a complete instruction book. But listed as major and frequent writing tasks are contract approval correspondence, data or "figuring" books, and trip reports. Somewhat less frequent jobs are patent disclosures and trouble correspondence. Unfortunately, technical article writing seems to get an even smaller share of time—a fact which we deplore.

What's Electronic?

Engineering editors tend to be philosophers (argumentative philosophers, we might add) on certain nebulous engineering questions. The latest discussion raging through the inner sanctum sanctorum is, "What's electronic?" Gone are the days when the distinguishing feature of an electronic device was a vacuum tube. In these days of transistors, semiconductors, magamps and similar "electronic?" devices, no one knows when a simple electrical gadget is going to kick up its heels and proudly declare that it's really "electronic." For instance, one of the fellows brought in a gadget his wife just purchased—a "Dazey Deluxe Can Opener with Dual Electronic Lid Lifter." No vacuum tubes and no transistors justified the title, just a simple two-pole permanent magnet.

This Month's Cover

Most engineers are familiar with the comparatively simple seals used to keep fluids out (or in). But sealing gases is a tricky and complex problem. The engineering concoctions worked out to keep steam, air or gas from escaping would delight the heart of a prison warden. Artist George Farnsworth has shown two—a segmental carbon-ring seal, and a labyrinth seal. You can find more in Donald Crego's article on Page 162.

MACHINE DESIGN

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BPA NBP

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Advertising and editorial content itemized for convenience when studying specific design problems

(*Concluded on Page* 10)

for

Exacting

CYLINDER CONTROL

¼" UNITITE JR. VALVES

Hanna ¼" Valves control air, oil or water pressures up to 500 p.s.i. The control lever requires only 80° movement for reversal. Hanna ¼" Valves are 4-way but can be made 3-way, by plugging one port. Three models — column, standard and manifold mount—are available. Ideal for tubing and light piping.

ELECTRIC VALVES

The Hanna 4-way Solenoid Valve is small, compact, with low current consumption. It is adaptable to straight line piping—capacity is equal to rated pipe size. Of balanced spool type, it has a built-in solenoid pilot valve. Piping may be from bottom, sides or a combination. Available in ⅜", ½", ¾" and 1" pipe sizes.

Hanna® valves

CHOOSE FROM a broad selection of Hanna Valves to meet your requirements for exacting Air and Hydraulic control. Illustrated are but a few of the complete line of hand, foot, electric and pilot operated valves for directional and speed control. They all carry the Hanna nameplate—an assurance of extraordinary care in design and manufacture—which means years of maintenance-free operation. Your Hanna sales representative offers specialized experience in selecting valve combinations and developing control circuits.

SEND FOR CATALOG

Hanna Valve Catalog No. 254 includes descriptions and specifications on the complete line.

SPEED CONTROL VALVES

Hanna Flo-Set Valves have micrometer graduations to assure exacting speed control. Available in ¼", ⅜", ½" and ¾" sizes, they are suitable for air, oil or water control, with maximum pressure to 250 p.s.i. They may be mounted in any position.

UNITITE VALVES

Unitite Valves are suitable as either 3-way or 4-way valves, operating at air, oil or water pressures up to 250 p.s.i. for the ⅜", ½", and ¾" sizes . . . up to 150 p.s.i. for the 1" size . . . and up to 100 p.s.i. for the 1¼" size. Three styles—for standard mounting, column mounting or manifold mounting—are available.

FOOT OPERATED VALVES

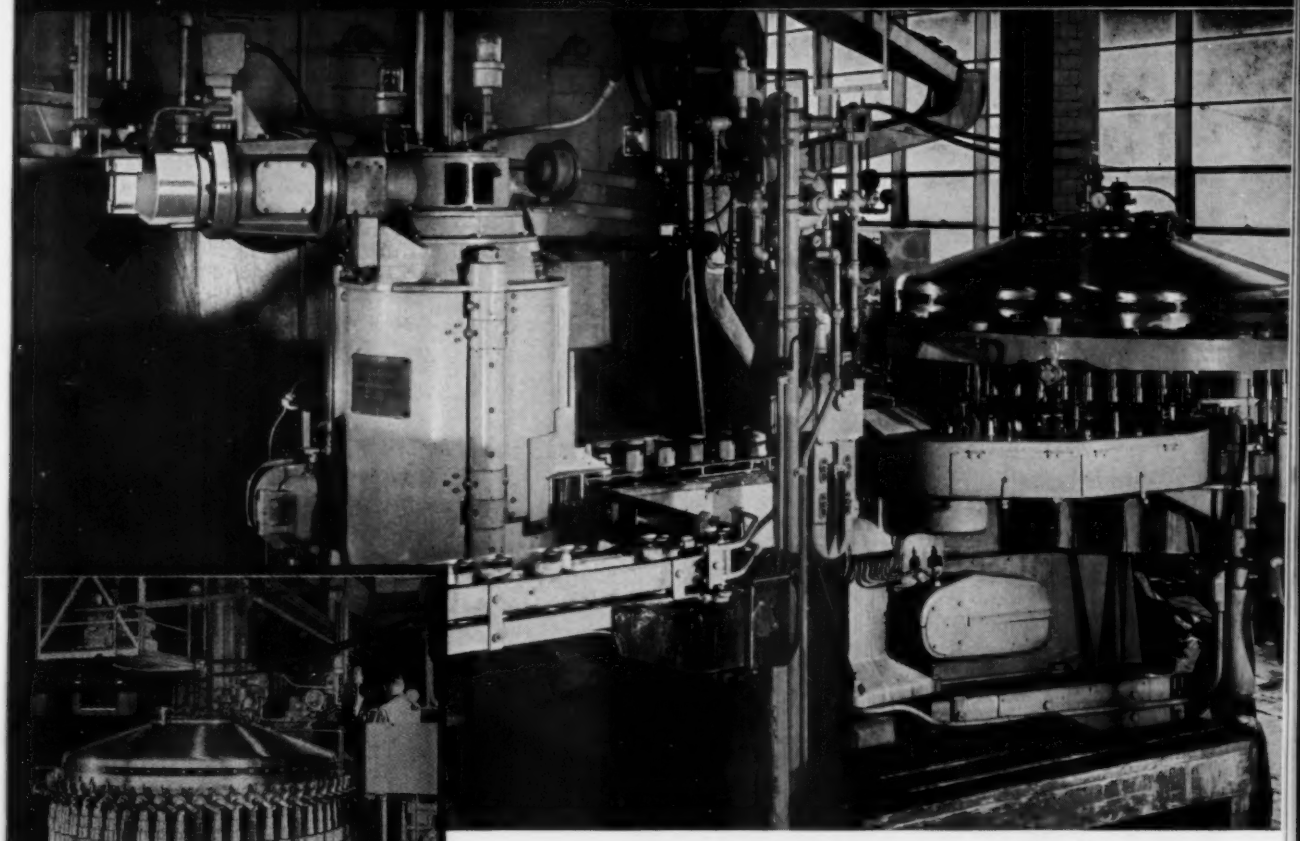
Available in ⅜", ½", ¾" and 1" pipe sizes, Hanna Foot Valves are ideal for applications where it is desirable to have the operator's hands free for handling material. Single-pedal and double-pedal models, for pressures up to 250 p.s.i., are available for use with double-acting air and hydraulic cylinders.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1751 Elston Avenue, Chicago 22, Illinois

You too can discover
THE WAY UP IS OILGEAR



Beer Can Filling and Closing Machines equipped with Oilgear "ANY-SPEED" Drives are operating in many breweries. With Oilgear, beer can filling and closing production climbed from 360 to 600 cans a minute.

OILGEAR
Fluid Power

PIONEERS...NOW THREE PLANTS FOR FLUID POWER

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS & VALVES

"ANY-SPEED" DRIVES BOOST FILLING-CLOSING RATE TO 600 BEER CANS PER MINUTE. SIMPLIFY MACHINE DESIGN TOO.

There is a necessity upon every machine designer to improve the performance of his machines—if he can. When the designers of beer-can filling and closing machines raised the rate from 150 to 360 cans per minute, the drive limit seemed to be reached. Yet, their users wanted more production *without spillage* or can conveyor problems.

Then these engineers tried Oilgear "ANY-SPEED" Drives... the Fluid Power and Control that gave them what they wanted and—even more.

These engineers stipulated: • accelerate machines to half speed in 2 seconds • accelerate machines to full speed in 5 seconds • decelerate and stop machines in 4/10 seconds • a filling-closing rate of 425 cans per minute.

The Oilgear drive accelerated and decelerated so smoothly, it actually provided: • acceleration to full speed in 2 seconds • deceleration and stop in 2/10 seconds • a filling-closing rate of 600 cans per minute.

That's not all. Oilgear's cushioned application of power plus inherent positive protection against high overload starting torques and lower overload running torques eliminated the need of mechanical slip clutches. Thus, the machine design is simplified and maintenance is negligible.

This smooth yet swift acceleration and deceleration that allows brewers to handle full cans without spilling is one of two tremendously important Oilgear advantages. Utterly variable, flexible and controllable speed is the other. These and other superiorities are writing new history in machine design. *You ought to know the details of that history.* Why don't you contact a nearby Oilgear engineer, or write to Milwaukee. No cost, but the profits may be great.

THE OILGEAR COMPANY
1568 W. Pierce Street
Milwaukee 4, Wisconsin

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(Concluded from Page 7)

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

Engineering News Roundup

New Stainless Steel Composition Disclosed

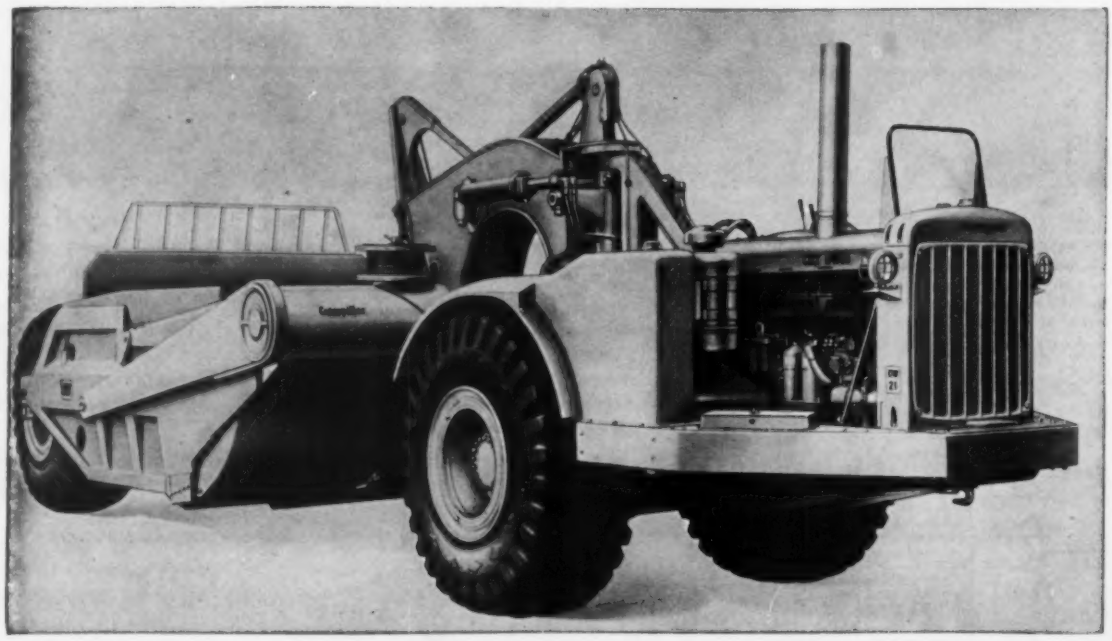
War Shortages Force Manganese Substitute

NEW YORK, N. Y. — Because of the nickel shortage in times of national emergency, stainless steel producers have developed two new stainless steels. Manganese has been substituted for part of the nickel in 18-8 stainless steel. Chemical composition in per cent of the new chromium - nickel - manganese stainless steels are:

Element	Type 201	Type 202
C (max)	0.15	0.15
Mn	5.5/7.5	7.5/10.0
P (max)	0.060	0.060
S (max)	0.031	0.031
Si (max)	1.00	1.00
Cr	16.0/18.0	17.0/19.0
Ni	3.5/5.5	4.0/6.0
N (max)	0.25	0.25

According to the American Iron and Steel Institute, refinements were made in this basic composition recently, which resulted in acceptance of the new steels. They are expected to be used for substantial applications where Types 301 and 302 are now being used.

Development work covering the substitution of manganese for part of the nickel in 18-8 stainless steel was started during World II.



LOWBOWL DESIGN of this new Caterpillar DW-21 scraper is said to allow faster loading with less lifting power. Scraper is also wider and longer than previous models. A new six-cylinder diesel engine rated 300 hp at 1800 rpm powers the machine. Engine exhaust drives a turbocharger for additional horsepower. Paper type fuel filters are another new feature said to reduce operating costs

If you're eating your heart out over polishing costs---read this!

Skyrocketing enthusiasm of America's homeowners for high-quality solid-brass lighting fixtures created a temporary bottleneck in the polishing room of Globe Lighting Products, Inc., one of the leaders in the field. This production problem coincided with the introduction of Formbrite* to the metal-working industry a couple of years ago.

Globe's acceptance of this easy-to-polish fine-grain drawing brass was immediate and enthusiastic. Results were highly successful from the very beginning. Work pile-ups in the polishing room were eliminated and polishing costs were cut in half on many items (see typical examples below). In addition, Globe learned, as have many others, that Formbrite provides a more lustrous finish—is harder, stronger, springier and more scratch-resistant, yet has remarkable ductility for forming and drawing operations.

Surprisingly, Formbrite doesn't cost a penny more than ordinary drawing brass. Why not pass the good news along to those who head up your engineering, design or production departments? Ask them to write for booklet B-39 . . . or phone for a sales representative . . . or request a free sample of Formbrite to try in your own shop. Address: The American Brass Company, General Offices, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

5580

*Reg. U. S. Pat. Off.

Parts illustrated are approximately three-quarters actual size.

48% saving 5/16 x .062" round-edge Formbrite strip in this scroll eliminated a before-bending polishing operation.

26% saving Tens of thousands of these drawn canopies, socket cups, etc., have been made of time-and-cost-saving Formbrite.

45% saving After forming, this Formbrite channel edging is simply bright dipped, color buffed, degreased, lacquered. That's all!

55% saving This hard-to-handle ornamental banding now gets only a simple color buff, saving as much as the cost of the metal.

Formbrite
FINE-GRAIN DRAWING BRASS
an ANACONDA product
made by The American Brass Company

ROUNDUP FEATURE REPORT

Engineers' Starting Salaries Hit New High

Studies Show Gain Of About 4 Per Cent

The shortage of engineers is no myth, judging by campus recruiting this past spring. Continuing a trend of several seasons, holders of fresh bachelor degrees were almost matched in number by the recruiters, and found their degrees worth new highs in average starting salaries.

Though universities reported significant differences according to curricula, the average starting rate proved to be between $380 and $385 per month. This figure is about $15 higher than one year ago, $100 higher than five years ago.

These average figures show a trend, but a look at a whole graduating class — engineering, arts, business—is even more revealing. E. A. Teal, director of placement for Lehigh University, Bethlehem, Pa., has analyzed the record for the June, 1955, class at Lehigh. Results are shown in the accompanying tables. Excluded from the data are two starting rates above $500 per month ($585 and $800).

Salary Offered Versus Accepted: Lehigh Graduates

Curriculum	1955 Accepted	1955 Offered	1954 Accepted	1954 Offered
Mech. Eng.	$377	$374	$361	$363
Elec. Eng.	396	386	374	371
Ind. Eng.	386	382	370	367
Eng. Physicist	396	388	367	361
Civil Eng.	375	377	373	366
Chem. Eng.	378	381	352	357
Chem.	382	387	365	365
Met. Eng.	378	375	365	362
Mining Eng.	380	370	365	362
All Eng.	383	378	366	364
Arts	354	358	334	323
Business	342	343	335	334
Total	371	374	358	358

Offers outnumbered available men by two or three to one. Salaries shown are averages.

Starting in the fall and continuing into the spring, 437 representatives of 327 companies visited the Lehigh campus to interview 481 students. About 11 interviews per student was the average. A student entertained an average of 1.8 definite job offers before making his final choice.

Obviously many more jobs were offered than accepted. Jobs offered averaged about $5 per month lower than the jobs accepted.

No new gimmicks were proffered as extra inducements. Fringe benefits seem to be so nearly universal that they were not active talking points. However, some companies bidding in the middle range were able to discuss profit sharing or other bonus features that promised up to $600 per year extra. Many companies paid expenses to the new job location.

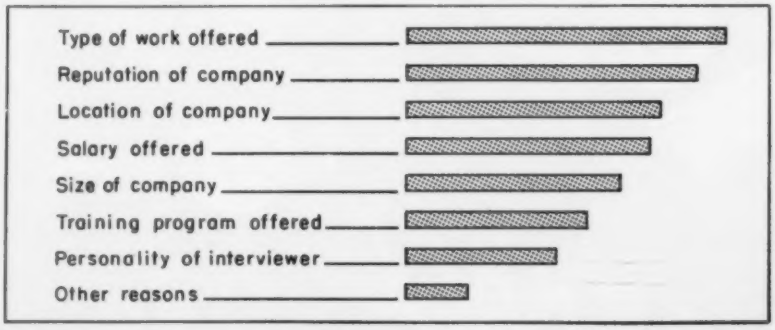
Despite the replies of graduates on why they accepted the jobs they did, there was quite evidently more involved in the decision than shown on the accompanying bar graph. Ben F. McClancy, general manager of Associated Industries of Cleveland, quotes a placement director's answer to the question, "Why do graduate engineers pick the companies they do?" The answer: "Time after time our graduates pick the organization that (1) selects its people on an individual basis, regardless of how few or many engineers it may need, and (2) does not hire from hysteria or statistical need."

The experience of more than one company bears out this approach. A medium-sized company, for example, undertook an aggressive recruiting program this past season. Looking for eventual managerial talent, they concentrated their attention upon the "cream" of several universities. Although only half the quota was filled, the company was pleased with the seven men they obtained. All were outstanding, scholastically and in campus activities. They started at $370, slightly below the $380-385 par.

It appears that bidding for fresh graduates in the recruiting season about to open will be no less active than in recent years. Most influences point toward a continuing

Starting Monthly Salary Distribution: Lehigh Graduates

Quartile	ME	EE	All Eng.	Arts	Bus.	Total
Highest	390–420	405–500	390–500	385–400	375–400	390–500
Second	375–390	400–405	380–390	375–385	345–375	375–390
Third	370–375	385–390	370–380	335–375	320–345	350–375
Lowest	335–365	350–380	320–370	280–335	200–320	200–350
Mean	377	396	383	354	342	371
Increase over '54						
Dollars	16	22	17	20	7	13
Per cent	4.4	5.8	4.6	5.9	2.0	3.6



Response of Lehigh engineering graduates when asked to rate the factors which influenced job selection

HOW TO AUTOMATE A GREASE JOB

Here is one of the latest marvels of automated production. This 21 station automatic transfer machine, manufactured by Snyder Tool & Engineering, Detroit, Michigan, machines 130 intake manifolds an hour. To guard this expensive equipment against wasteful down-time, it is lubricated *automatically* with a TRABON Central Lubrication System.

TRABON systems are ideal when man hours are important! A simple, centrally located control provides the correct amount of lubrication to every bearing, automatically. The sealed, pressurized system locks out dirt and foreign matter and prevents chips from working between bearing surfaces.

TRABON designs systems for all types of machine tools. Whether your machine is a drill press or a giant automated line, there is a TRABON system to fit your needs.

Write for machine tool bulletin 5410.

Trabon ENGINEERING CORPORATION
1814 E. 40th STREET • CLEVELAND 3, OHIO
Oil and Grease Systems

advance in starting rates.

Demand for men continues high with no substantial increased supply in sight. Many fellows starting out on training courses this past summer had no sooner endorsed their first pay checks when notified of raises. Some companies increased trainee rates at the same time new union contracts became effective. In some of these cases, as a consequence, the automatic starting rates for next year's new crop were pushed to over $400.

The federal government is also entering the new graduate market in a very positive fashion. It's claimed that at least 10,000 government jobs paying up to $400 plus to start will be available to 1956 graduates. At McClellan Air Force Base, for example, Civil Service openings for engineers fresh out of school are starting at $362, and with at least six month's experience, $411. Moreover, no written test is required; to qualify, applicants must only show appropriate education and experience.

Several overtones have come from this continuing rise in fortune of new graduates. Placement officials at some of the universities find that their "active" alumni lists are growing. Men out three to five years are checking back with the schools and attempting to find better-paying jobs: "No experience gets $400; I'm getting less than $500."

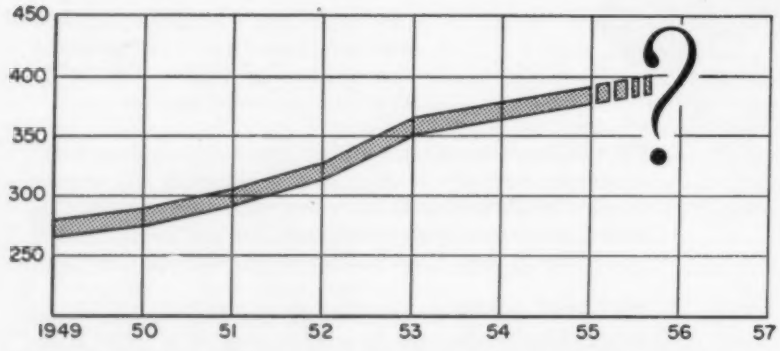
Northwestern University's director of placement, F. S. Endicott, recently reported the results of a survey of men five years out of school. He received reports from 193 companies on "truly typical graduates of the class of 1949" who have made "average progress." Here are the results:

Field	Start. Sal.	1954 Sal.	Ratio
Engineering	$270	$513	1.90
Accounting	244	484	1.98
Sales	254	547	2.15
Gen. Bus.	238	477	2.00

Similarly, 97 companies selected the one man hired five years before who now seems to have the "most potential for top executive responsibility."

Field	Start. Sal.	1954 Sal.	Ratio
Engineering	$274	$607	2.22
Commerce	263	666	2.53
Liberal arts	254	679	2.67

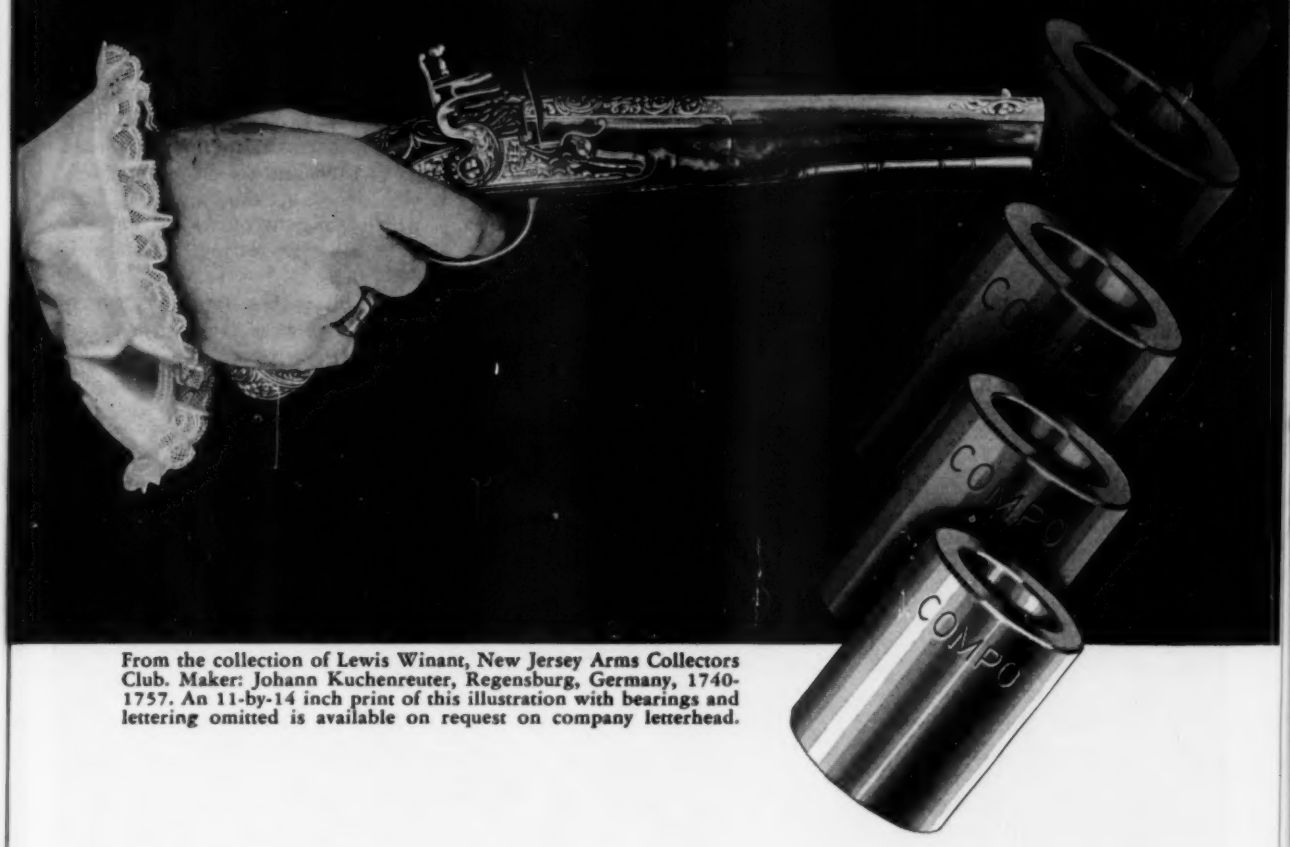
In these data, presumably both nonsupervisory and supervisory personnel are included. An obvious observation is that the business or arts graduate has experienced a more rapid gain in earning power than the engineer—whether typical or outstanding.



Trend of monthly starting salaries for engineering graduates. In 1955, the "middle" 50 per cent of the graduates started in a range of about $370 to $390 per month

Weathering test program for porcelain enamels will be expanded, announced John C. Oliver, secretary of the Porcelain Enamel Institute. Purpose of the program, which began 15 years ago as a project of the Enameled Metals Section of the National Bureau of Standards, is to test many different types of porcelain enamels to determine how, and to what extent, they are affected by weathering under different climatic conditions over specified periods of time.

Point of Honor



From the collection of Lewis Winant, New Jersey Arms Collectors Club. Maker: Johann Kuchenreuter, Regensburg, Germany, 1740-1757. An 11-by-14 inch print of this illustration with bearings and lettering omitted is available on request on company letterhead.

In today's business dealings (as in yesterday's "affairs of honor") both parties are protected by an intangible factor known as INTEGRITY—a figurative handsake between producer and consumer. Today, this point of honor assures you that the product you buy is exactly as represented. When you write COMPO Oil-Retaining Porous Bronze Bearings into your specifications you find that it is a point of honor with Bound Brook, as a reliable manufacturer, to provide you with the best powder metallurgy bearings that can be produced.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

Giant Extrusion Press Assembled for Tests

Air Force Press
Largest Built in U.S.

YOUNGSTOWN, O.—Built as part of the U. S. Air Force heavy press program, a new 12,000-ton extrusion press was assembled here for preliminary testing recently. Fabricated for the Lombard Corp. by United Engineering and Foundry Co., the press is the largest built entirely in the U.S.

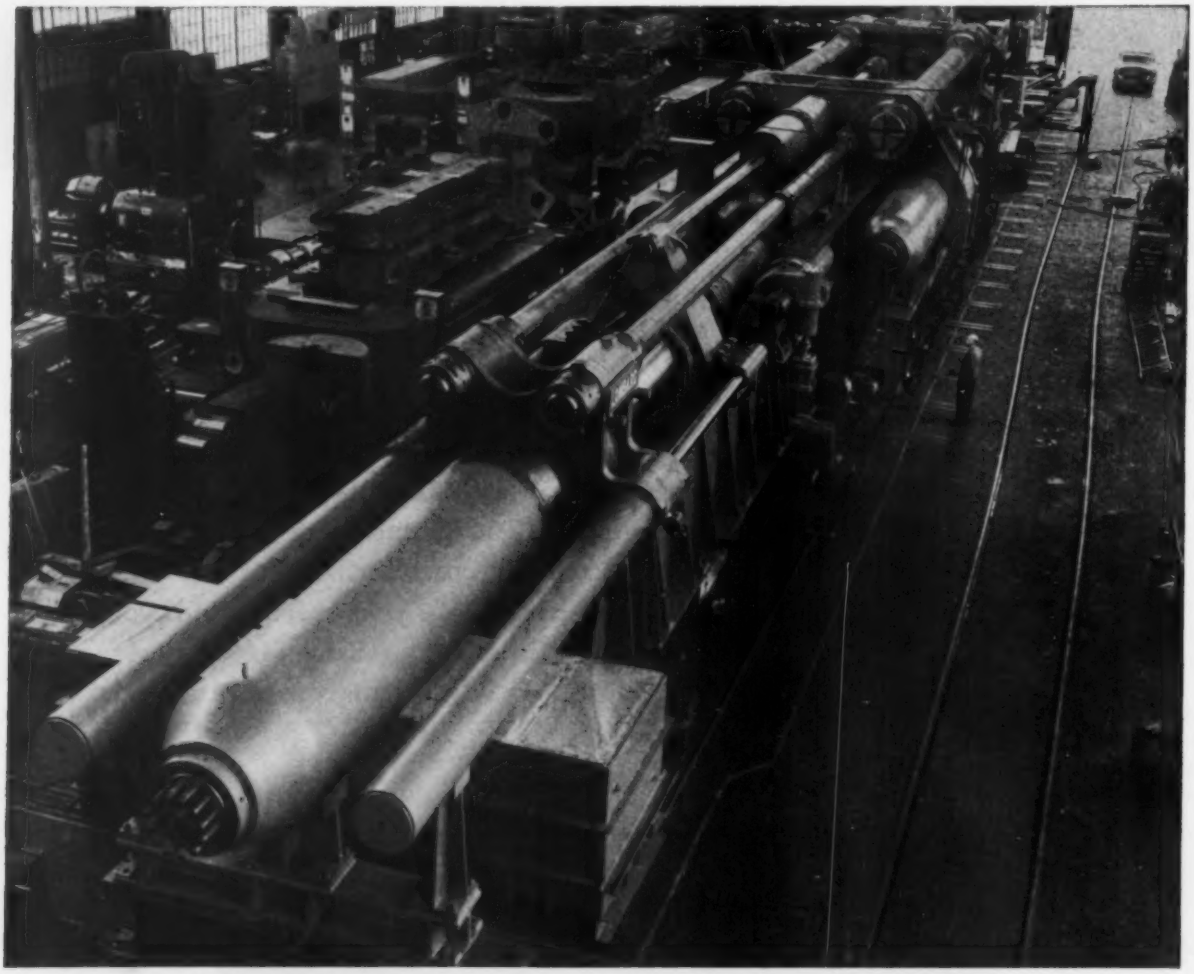
Designed primarily to extrude aluminum, the press will eventually be used for extrusion of both steel and titanium. While the 12,000-ton capacity is the sum of three pressure-cylinder systems, each can be used in combination with others to produce lower tonnages. For example, the main cylinder alone will produce 4500 tons, main and piercer cylinders together produce 7500 tons, and the main and lateral cylinders add up to 9000 tons.

Overall length of the machine is just over 300 ft with the runout table. Overall weight is 2000 tons. Stroke of the main ram is 13 ft 4 in., and stroke of the piercer ram is 20 ft 2 in. Maximum diameter of aluminum billets is 32 inches and a maximum length, 70 inches. Extrusion speed is about 7 in. per sec.

Four operators will be required for most operations. Control of the press can be set up for semi-automatic programming.

Two accumulator bottles, each 52 ft high and 52 inches in diameter, contain the pressure fluid which consists of water and soluble oil. Operating pressure is 4285 psi.

Special valves having a balancing feature were designed by Lombard. Purpose of the balancing feature is to allow easier manual operation. Valves were designed



Overall view of the assembled Lombard 12,000 ton extrusion press. After preliminary testing, it will be disassembled and shipped to Harvey Aluminum at Torrance, Calif.

to include a motor operator drive with a servo selsyn remote control system.

Final installation of the press will be at Harvey Aluminum, Torrance, Calif. Because of the size of some of the components, a special railway car had to be designed. Average speed of the equipment across the country by rail will be 12 mph, not including stops.

Flux Adds Alloys To Weld Deposit

Custom-Made Fluxes Allow Varied Alloy Deposit

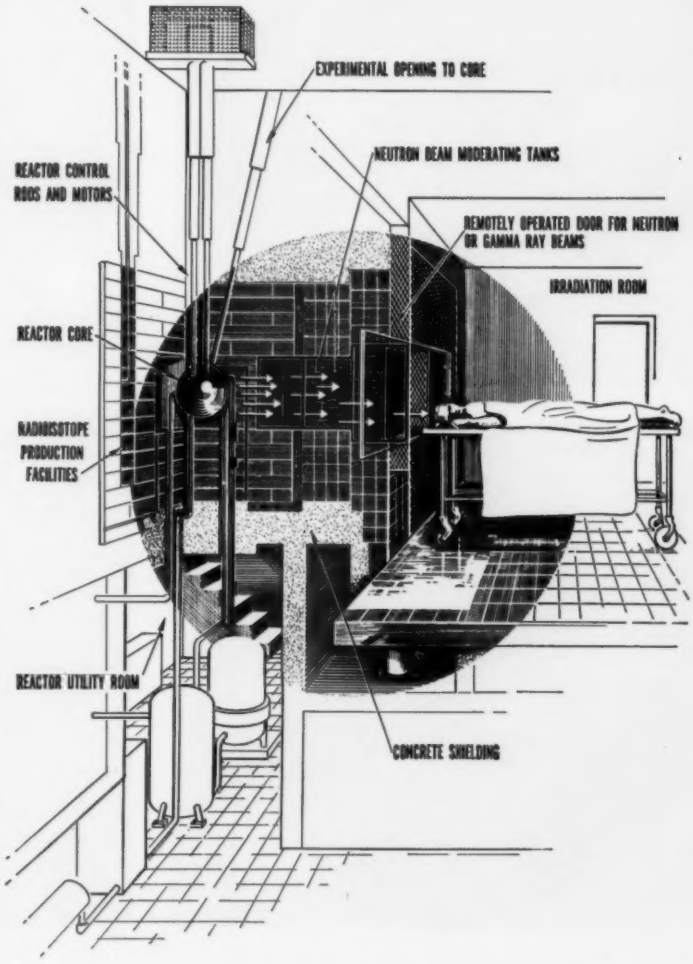
CLEVELAND, O. — Individually compounded alloy welding fluxes make changes of alloying elements possible as required for a particular job. New agglomerated fluxes, recently announced by Lincoln Electric Co., are said to be a new approach to meeting the requirements of welding complex and highly specialized steels. The fluxes are said to be specially adapted to automatic submerged-arc welding methods.

These new fluxes, through the process of agglomeration, contain alloying elements which may be changed as required. Used with a mild-steel electrode, the fluxes will produce a low-alloy deposit that can be readily varied.

When an alloy electrode is used, additional alloys needed to control dilution may be added through the flux. Adding alloys to the weld deposit through the flux rather than the wire is claimed to be more economical. Large and small quantities of flux can be produced quickly as compared to the production of alloy wire. Another advantage is said to be the ability to make small changes in deposit analysis through the welding procedure control without changing either the flux or wire composition.

Among the compounding elements that may be included in the fluxes are chromium, molybdenum, vanadium and nickel. They may be used for welding low-alloy steels, according to Lincoln Electric, those steels generally classified as containing less than 6 per cent alloy.

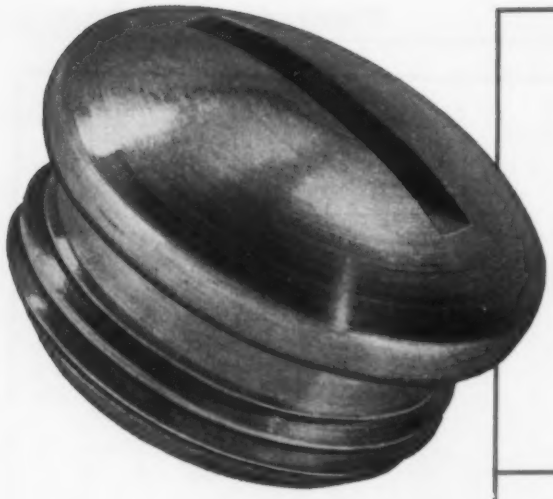
Some suggested applications of the new fluxes include welding chrome-moly pipe for high-temperature service and steels such as ASTM specification A335-53, alloys P-2, P-3, P-3b, P-11, P-12 and P-22; also ASTM specification A301-53, grades A and B. Other applications include welding of the newer highly complex, high-strength alloy steels and armor steels.

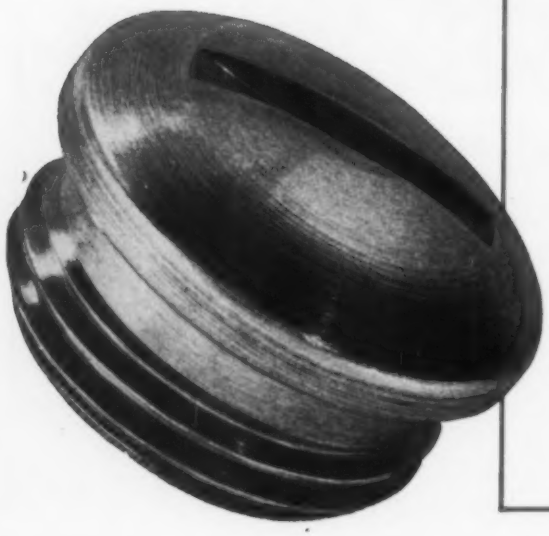


MEDICAL REACTOR designed by North American Aviation Inc. will be built for the Medical Center of the University of California at Los Angeles. Gamma rays and neutrons will be produced for medical uses, although the reactor is also designed for nonmedical uses. Said to be the first reactor designed for medical research, the unit is scheduled for completion in about a year. It will operate at a power level of 5 kw with a maximum power of 50 kw. Fuel will consist of 4 gallons of uranyl sulphate solution highly enriched in uranium 235

Linde Air Products Co., Div. of Union Carbide and Carbon Corp. is building a $15 million plant at Long Beach, W. Va. for the production of silicones.

(*Continued on Page 24*)





Manufacturing data and costs—**ALUMINUM**

MACHINE: Browne & Sharpe, Model OG (Chain Drive)
OPERATING DATA: (this job)

Turning:	Spindle Speed	4230 rpm (forward)
	Surface Feet	692 per minute
Threading:	Spindle Speed	1365 rpm (forward)
	Surface Feet	200 per minute

OPERATIONS: Feed - clear - form & face - center - index - drill - index - combination flat bottom drill & chamfer - index - die on - cutoff - pickup & slot

CYCLE TIME: 5⅔ seconds **PARTS PER HOUR:** 635
EFFICIENCY: 80%
STOCK: ⅝" round, 2011—T3 (11ST-3) Aluminum

Weight per foot	.3748 pounds
Stock weight per 1,000 pcs.	15.6 pounds
Cost per pound (156 lbs.)	$0.701

TOOLING COST: $18.40 (same as for brass)

TOTAL COST: SET UP		$ 1.90
LABOR, INSPECTION, OVERHEAD, ETC.		15.00
MATERIAL: Stock 15.6# @ $.701/#	$11.04	
*Less scrap (60%)—9.36# @ 13¢/#	1.22	
NET COST	$ 9.82	9.82
TOTAL COST . per 1,000 in lots of 10,000		$26.72

*Typical Chicago Area scrap prices on 5-9-55.

Manufacturing data and costs—**BRASS**

MACHINE: Browne & Sharpe, Model OG (Chain Drive)
OPERATING DATA: (this job)

Turning:	Spindle Speed	4230 rpm (forward)
	Surface Feet	692 per minute
Threading:	Spindle Speed	1365 rpm (forward)
	Surface Feet	200 per minute

OPERATIONS: Feed - clear - form & face - center - index - drill - index - combination flat bottom drill & chamfer - index - die on - cutoff - pickup & slot

CYCLE TIME: 5⅔ seconds **PARTS PER HOUR:** 635
EFFICIENCY: 80%
STOCK: ⅝" round, free machining yellow brass

Weight per foot	1.133 pounds
Stock weight per 1,000 pcs.	46.8 pounds
Cost per pound (468 lbs.)	$0.5022

TOOLING COST: $18.40 (same as for aluminum)

TOTAL COST: SET UP		$ 1.90
LABOR, INSPECTION, OVERHEAD, ETC.		15.00
MATERIAL: Stock 46.8# @ $.5022/#	$23.50	
*Less scrap (60%) 28.1# @ 22¢/#	6.18	
NEW MATERIAL COST	$17.32	17.32
TOTAL COST . per 1,000 in lots of 10,000		$34.22

*Typical Chicago Area scrap prices on 5-9-55.

COST OF PART PER 1,000 IN LOTS OF 10,000	**IN BRASS**	**$34.22**
	IN ALUMINUM	**26.72**
	SAVING PER 1,000	**$ 7.50**
	21.9% SAVED ON THIS ONE PART!	

FOR BIG SAVINGS LIKE THESE...

WHEN YOU ASK your screw machine supplier to bid in Kaiser Aluminum instead of brass or steel, you make it possible for him to offer you big savings. Here's why:

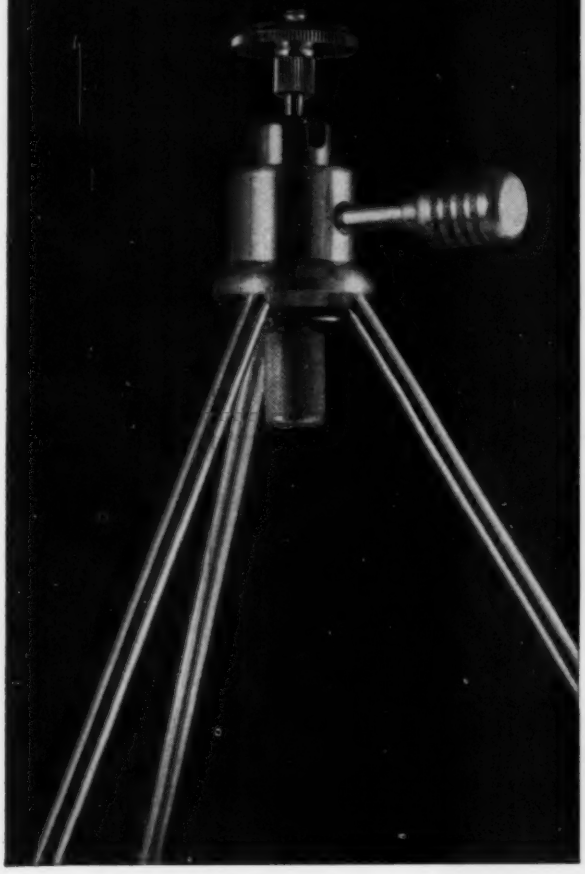
Each aluminum part can cost you *less*, because your supplier gets *three times* as many parts from a pound of Kaiser Aluminum stock as from a pound of brass or steel.

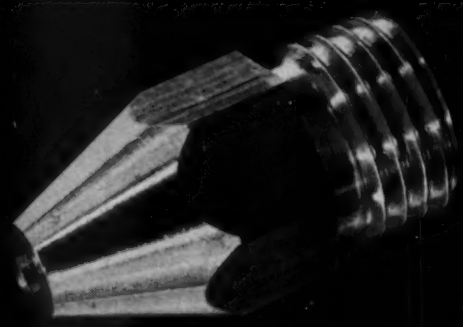
In addition, Kaiser Aluminum stock permits other economies that benefit you. Because of its lighter weight, your shipping and mailing costs are less. And aluminum often reduces machine time, extends tool life, and eliminates expensive plating—*savings that can be passed on to you!*

You can get *better* parts—because aluminum provides a unique combination of advantages, including lightness combined with strength, handsome finish, corrosion resistance, good heat and electrical conductivity.

For more information or assistance, contact the Kaiser Aluminum Sales Office listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Building, Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

34.1% saved on six parts of this tripod by using Kaiser Aluminum stock instead of brass. 18.5% saved when used instead of steel.





25.6% saved on this nozzle by using Kaiser Aluminum stock instead of brass.

35% saved on this swivel by using Kaiser Aluminum stock instead of steel.

THINK OF *Kaiser Aluminum*

Why you can specify Kaiser Aluminum with confidence

Screw machine operators all over the country find aluminum easy to machine on any existing screw machine at both high and low speeds. Only a few easy changes are required to work aluminum instead of other materials.

And to help screw machine shops machine aluminum most effectively, Kaiser Aluminum engineers are available to recommend machining practices proved best by operators experienced in aluminum.

On your future screw machine parts bids, always ask your supplier to give you the price in aluminum. The savings will be big, and the quality will probably be better!

advance in starting rates.

Demand for men continues high with no substantial increased supply in sight. Many fellows starting out on training courses this past summer had no sooner endorsed their first pay checks when notified of raises. Some companies increased trainee rates at the same time new union contracts became effective. In some of these cases, as a consequence, the automatic starting rates for next year's new crop were pushed to over $400.

The federal government is also entering the new graduate market in a very positive fashion. It's claimed that at least 10,000 government jobs paying up to $400 plus to start will be available to 1956 graduates. At McClellan Air Force Base, for example, Civil Service openings for engineers fresh out of school are starting at $362, and with at least six month's experience, $411. Moreover, no written test is required; to qualify, applicants must only show appropriate education and experience.

Several overtones have come from this continuing rise in fortune of new graduates. Placement officials at some of the universities find that their "active" alumni lists are growing. Men out three to five years are checking back with the schools and attempting to find better-paying jobs: "No experience gets $400; I'm getting less than $500."

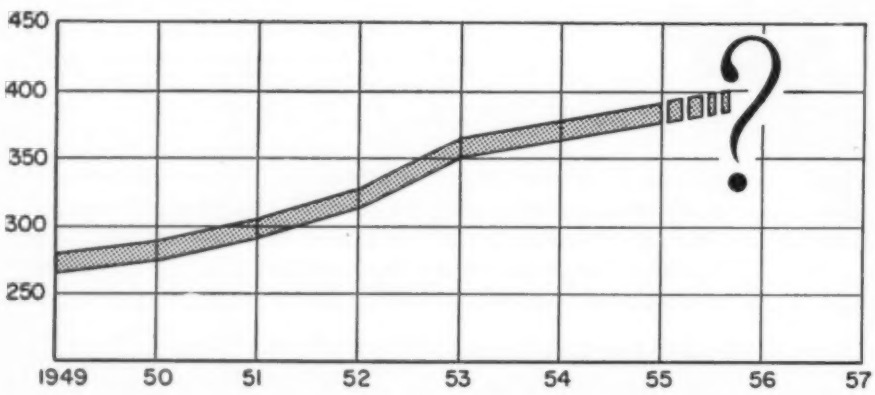
Northwestern University's director of placement, F. S. Endicott, recently reported the results of a survey of men five years out of school. He received reports from 193 companies on "truly typical graduates of the class of 1949" who have made "average progress." Here are the results:

Field	Start. Sal.	1954 Sal.	Ratio
Engineering	$270	$513	1.90
Accounting	244	484	1.98
Sales	254	547	2.15
Gen. Bus.	238	477	2.00

Similarly, 97 companies selected the one man hired five years before who now seems to have the "most potential for top executive responsibility."

Field	Start. Sal.	1954 Sal.	Ratio
Engineering	$274	$607	2.22
Commerce	263	666	2.53
Liberal arts	254	679	2.67

In these data, presumably both nonsupervisory and supervisory personnel are included. An obvious observation is that the business or arts graduate has experienced a more rapid gain in earning power than the engineer—whether typical or outstanding.



Trend of monthly starting salaries for engineering graduates. In 1955, the "middle" 50 per cent of the graduates started in a range of about $370 to $390 per month

Weathering test program for porcelain enamels will be expanded, announced John C. Oliver, secretary of the Porcelain Enamel Institute. Purpose of the program, which began 15 years ago as a project of the Enameled Metals Section of the National Bureau of Standards, is to test many different types of porcelain enamels to determine how, and to what extent, they are affected by weathering under different climatic conditions over specified periods of time.

Point of Honor

From the collection of Lewis Winant, New Jersey Arms Collectors Club. Maker: Johann Kuchenreuter, Regensburg, Germany, 1740-1757. An 11-by-14 inch print of this illustration with bearings and lettering omitted is available on request on company letterhead.

In today's business dealings (as in yesterday's "affairs of honor") both parties are protected by an intangible factor known as INTEGRITY—a figurative handsake between producer and consumer. Today, this point of honor assures you that the product you buy is exactly as represented. When you write COMPO Oil-Retaining Porous Bronze Bearings into your specifications you find that it is a point of honor with Bound Brook, as a reliable manufacturer, to provide you with the best powder metallurgy bearings that can be produced.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

Giant Extrusion Press Assembled for Tests

Air Force Press
Largest Built in U.S.

YOUNGSTOWN, O.—Built as part of the U. S. Air Force heavy press program, a new 12,000-ton extrusion press was assembled here for preliminary testing recently. Fabricated for the Lombard Corp. by United Engineering and Foundry Co., the press is the largest built entirely in the U.S.

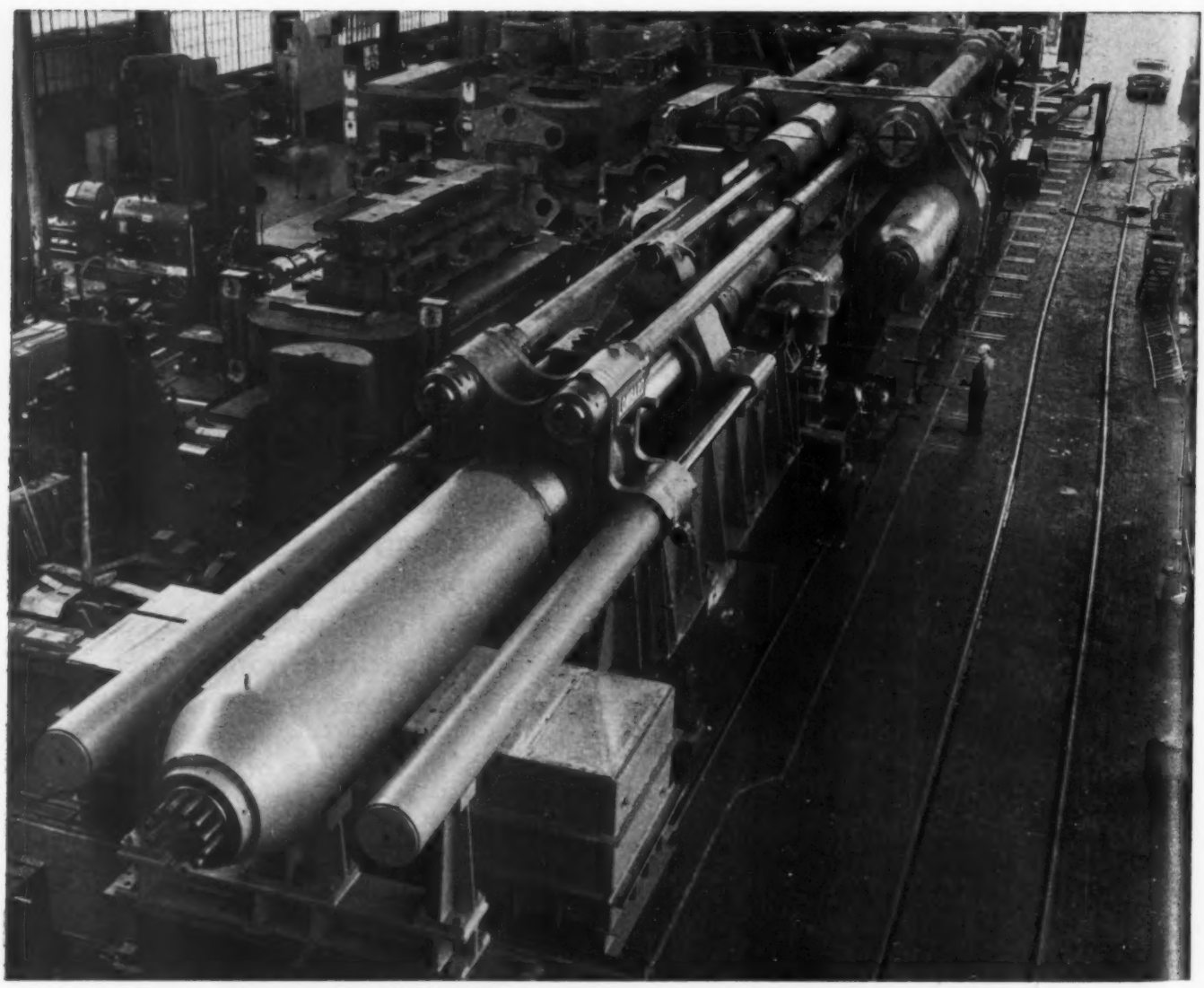
Designed primarily to extrude aluminum, the press will eventually be used for extrusion of both steel and titanium. While the 12,000-ton capacity is the sum of three pressure-cylinder systems, each can be used in combination with others to produce lower tonnages. For example, the main cylinder alone will produce 4500 tons, main and piercer cylinders together produce 7500 tons, and the main and lateral cylinders add up to 9000 tons.

Overall length of the machine is just over 300 ft with the runout table. Overall weight is 2000 tons. Stroke of the main ram is 13 ft 4 in., and stroke of the piercer ram is 20 ft 2 in. Maximum diameter of aluminum billets is 32 inches and a maximum length, 70 inches. Extrusion speed is about 7 in. per sec.

Four operators will be required for most operations. Control of the press can be set up for semi-automatic programming.

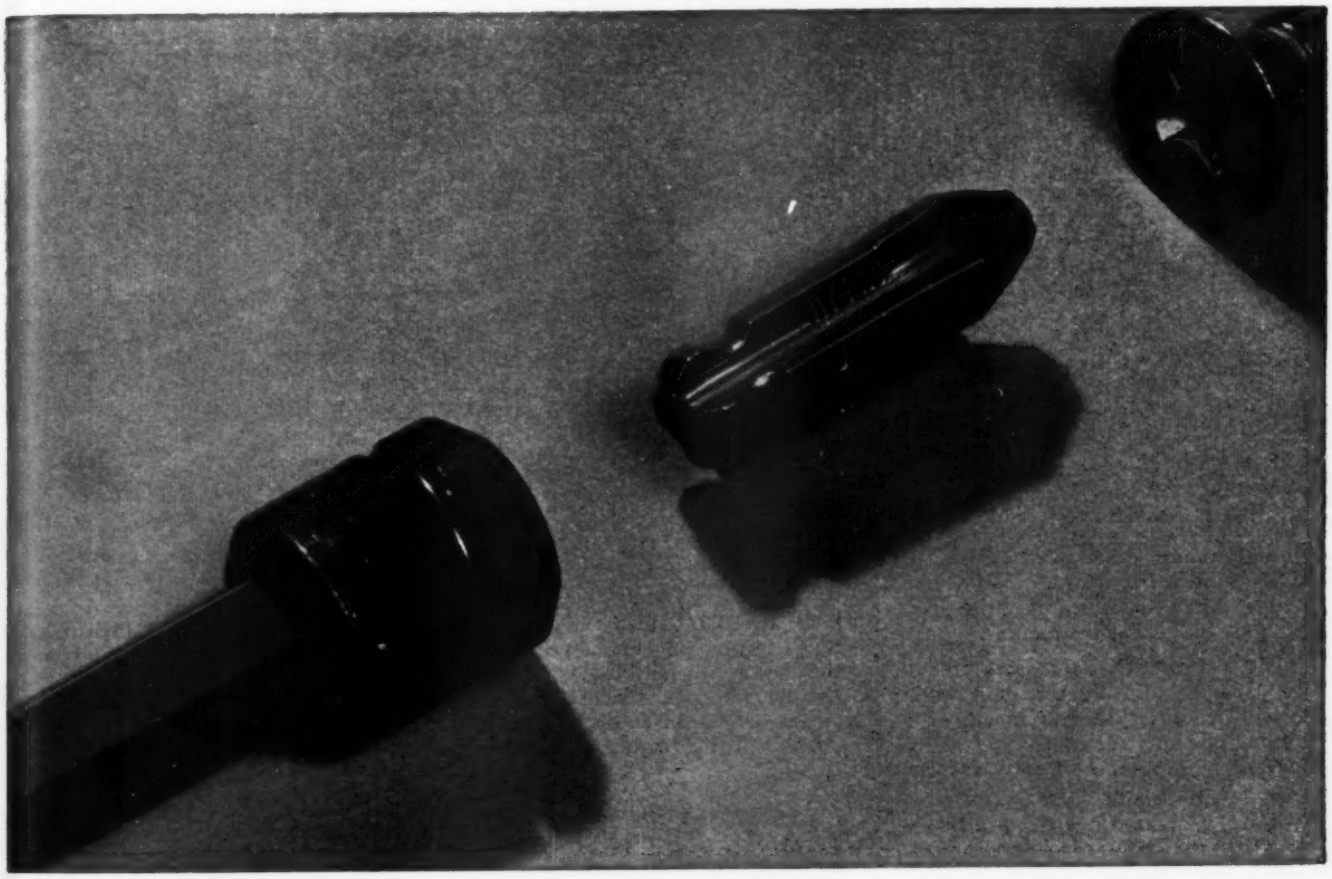
Two accumulator bottles, each 52 ft high and 52 inches in diameter, contain the pressure fluid which consists of water and soluble oil. Operating pressure is 4285 psi.

Special valves having a balancing feature were designed by Lombard. Purpose of the balancing feature is to allow easier manual operation. Valves were designed



Overall view of the assembled Lombard 12,000 ton extrusion press. After preliminary testing, it will be disassembled and shipped to Harvey Aluminum at Torrance, Calif.

YOU CAN COUNT ON CONTINENTAL FOR EVERY FASTENER NEED!



Phillips *"Bits–Holders–Screws"* are Exclusive with Continental!

Here's how they can boost your output

Only the Continental Screw Co. offers this three-way fastening combination to increase your output. Phillips *bits, holders, and screws* now make power-driving really practical—even on your finished parts.

The Continental record speaks for itself. Continental Phillips Bits have driven as many as 1,000,000 screws without replacement. They average from 2 to 4 times longer life than other bits, and have cut fastening costs as much as 50%.

Send for this free booklet on Hy-Pro Phillips Insert Bits and Holders. Write to Continental Screw Co. New Bedford, Mass.

Continental Screw Co.

Manufacturers of Holtite Fastenings

NEW BEDFORD, MASSACHUSETTS, U. S. A.

HOWELL MOTOR BRIEFS

Quick facts for those who apply and specify electric motors

Rerated Motors: Both *smaller* . . . and *better!*

The compactness of the NEMA-rerated frame sizes has been enthusiastically received by designers generally. This new, smaller, cooler, and lighter motor has been designed *especially* to meet the new demands in *modern* machine requirements.

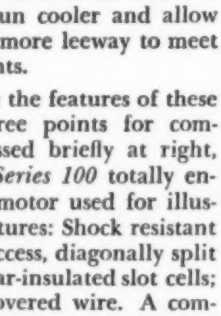
The problems of restricted space are more easily solved, together with easier installation in hard-to-get-at places. Handling is easier. Freight costs are reduced.

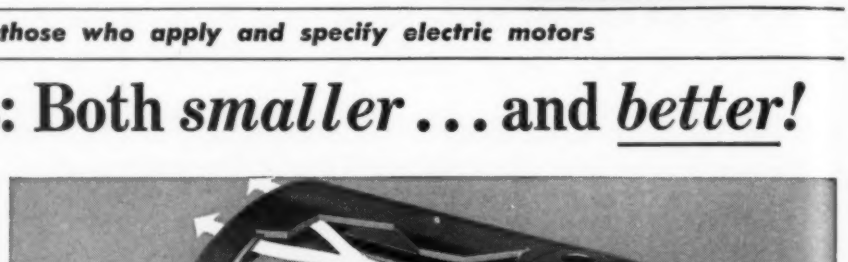
Howell's years of design experience, plus the scientific advances in insulation and other vital materials, have resulted in the new *Series 100* motors, often described as "the best industrial motor on the market!"

The resulting *Series 100* motors are not only smaller and lighter than their horsepower equivalents in the old frame sizes, but run cooler and allow Howell engineers more leeway to meet special requirements.

Note and compare the features of these new motors. Three points for comparison are discussed briefly at right, with the Howell *Series 100* totally enclosed fan-cooled motor used for illustration. Other features: Shock resistant steel frame; easy access, diagonally split terminal box; Mylar-insulated slot cells; and vinyl acetyl-covered wire. A compact, vibration resisting, trouble-free winding is assured by two dip and bake cycles, after stator preheating.

The *Series 100* open drip-proof motors are similarly outstanding. Howell's exclusive new stator design works heat-dissipation miracles here, too, and versatile, high-stability copper-bar rotors are standard throughout the line. Bearings in the open motors, while not cartridge-type, are double-shielded and sealed in the end-plate cavities by dust-tight inner caps. Howellube greasing system provides positive lubrication and ease of maintenance.





Good ventilation — one key to better design. "Cooler running" means longer motor life. Howell's new stator construction includes wide ventilation slots around the perimeter of the laminations. The steel frame completes the ducts which provide 50% more contact between the cooling flow of fan-driven air and the main source of heat, the stator, than ever before possible in any standard motor.

Fully protected bearings last longer. Dirt can't enter Howell's cartridge-type, double shielded bearings, either from inside or outside the motor. Cartridge remains sealed even when the end-plate is removed.

Copper-Clad rotors have better heat conductivity, more stability at high temperatures and greater design flexibility to meet special requirements than die-cast aluminum rotors. Howell uses copper exclusively.

Series 100 enclosures: totally enclosed fan cooled, open drip-proof, splash-proof and weather protected, sanitary, explosion-proof, and totally enclosed non-ventilated.

Write for new Bulletin N-100-R

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

to include a motor operator drive with a servo selsyn remote control system.

Final installation of the press will be at Harvey Aluminum, Torrance, Calif. Because of the size of some of the components, a special railway car had to be designed. Average speed of the equipment across the country by rail will be 12 mph, not including stops.

Flux Adds Alloys To Weld Deposit

Custom-Made Fluxes Allow Varied Alloy Deposit

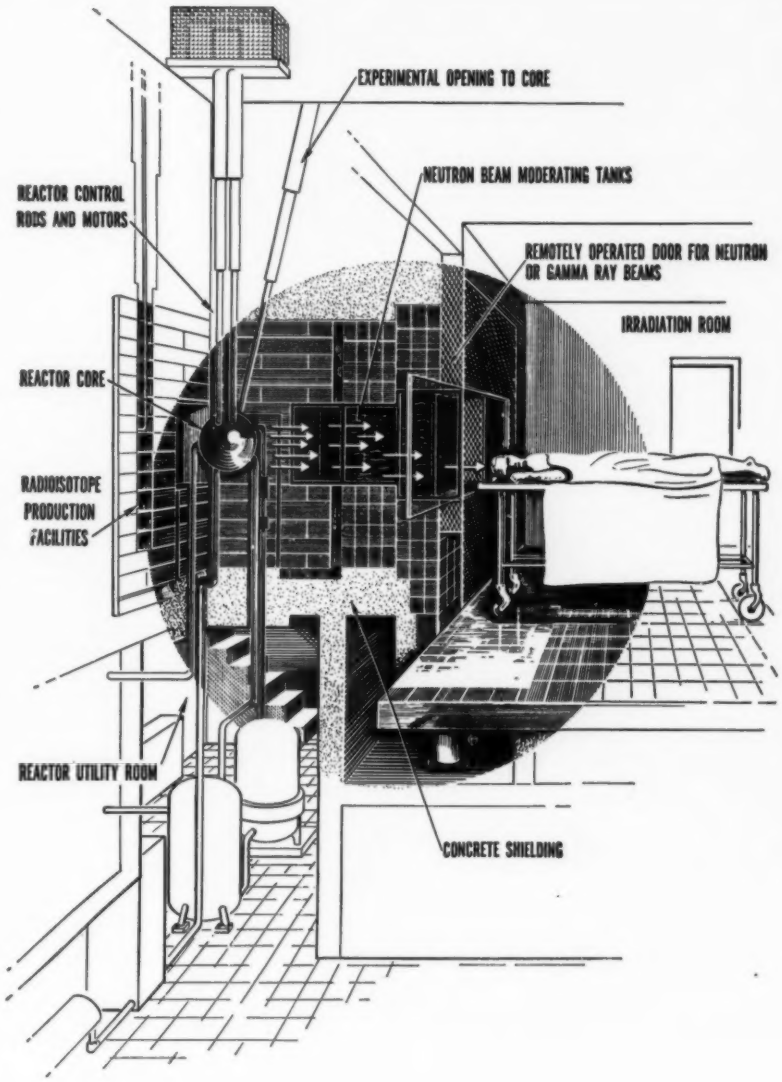
CLEVELAND, O. — Individually compounded alloy welding fluxes make changes of alloying elements possible as required for a particular job. New agglomerated fluxes, recently announced by Lincoln Electric Co., are said to be a new approach to meeting the requirements of welding complex and highly specialized steels. The fluxes are said to be specially adapted to automatic submerged-arc welding methods.

These new fluxes, through the process of agglomeration, contain alloying elements which may be changed as required. Used with a mild-steel electrode, the fluxes will produce a low-alloy deposit that can be readily varied.

When an alloy electrode is used, additional alloys needed to control dilution may be added through the flux. Adding alloys to the weld deposit through the flux rather than the wire is claimed to be more economical. Large and small quantities of flux can be produced quickly as compared to the production of alloy wire. Another advantage is said to be the ability to make small changes in deposit analysis through the welding procedure control without changing either the flux or wire composition.

Among the compounding elements that may be included in the fluxes are chromium, molybdenum, vanadium and nickel. They may be used for welding low-alloy steels, according to Lincoln Electric, those steels generally classified as containing less than 6 per cent alloy.

Some suggested applications of the new fluxes include welding chrome-moly pipe for high-temperature service and steels such as ASTM specification A335-53, alloys P-2, P-3, P-3b, P-11, P-12 and P-22; also ASTM specification A301-53, grades A and B. Other applications include welding of the newer highly complex, high-strength alloy steels and armor steels.



MEDICAL REACTOR designed by North American Aviation Inc. will be built for the Medical Center of the University of California at Los Angeles. Gamma rays and neutrons will be produced for medical uses, although the reactor is also designed for nonmedical uses. Said to be the first reactor designed for medical research, the unit is scheduled for completion in about a year. It will operate at a power level of 5 kw with a maximum power of 50 kw. Fuel will consist of 4 gallons of uranyl sulphate solution highly enriched in uranium 235

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(Continued on Page 24)

Manufacturing data and costs—**ALUMINUM**

MACHINE: Browne & Sharpe, Model OG (Chain Drive)
OPERATING DATA: (this job)

Turning:	Spindle Speed	4230 rpm (forward)
	Surface Feet	692 per minute
Threading:	Spindle Speed	1365 rpm (forward)
	Surface Feet	200 per minute

OPERATIONS: Feed - clear - form & face - center - index - drill - index - combination flat bottom drill & chamfer - index - die on - cutoff - pickup & slot

CYCLE TIME: 52⅔ seconds **PARTS PER HOUR:** 635
EFFICIENCY: 80%
STOCK: ⅝" round, 2011—T3 (11ST-3) Aluminum

Weight per foot		.3748 pounds
Stock weight per 1,000 pcs.		15.6 pounds
Cost per pound (156 lbs.)		$0.701
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TOTAL COST: SET UP		$ 1.90
LABOR, INSPECTION, OVERHEAD, ETC.		15.00
MATERIAL: Stock 15.6# @ $.701/#	$11.04	
*Less scrap (60%)—9.36# @ 13¢/#	1.22	
NET COST	$ 9.82	9.82
TOTAL COST . per 1,000 in lots of 10,000		$26.72

*Typical Chicago Area scrap prices on 5-9-55.

Manufacturing data and costs—**BRASS**

MACHINE: Browne & Sharpe, Model OG (Chain Drive)
OPERATING DATA: (this job)

Turning:	Spindle Speed	4230 rpm (forward)
	Surface Feet	692 per minute
Threading:	Spindle Speed	1365 rpm (forward)
	Surface Feet	200 per minute

OPERATIONS: Feed - clear - form & face - center - index - drill - index - combination flat bottom drill & chamfer - index - die on - cutoff - pickup & slot

CYCLE TIME: 52⅔ seconds **PARTS PER HOUR:** 635
EFFICIENCY: 80%
STOCK: ⅝" round, free machining yellow brass

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TOOLING COST: $18.40 (same as for aluminum)		
TOTAL COST: SET UP		$ 1.90
LABOR, INSPECTION, OVERHEAD, ETC.		15.00
MATERIAL: Stock 46.8# @ $.5022/#	$23.50	
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NEW MATERIAL COST	$17.32	17.32
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*Typical Chicago Area scrap prices on 5-9-55.

COST OF PART PER 1,000 IN LOTS OF 10,000	**IN BRASS**	**$34.22**
	IN ALUMINUM	**26.72**
	SAVING PER 1,000	**$ 7.50**

21.9% SAVED ON THIS ONE PART!

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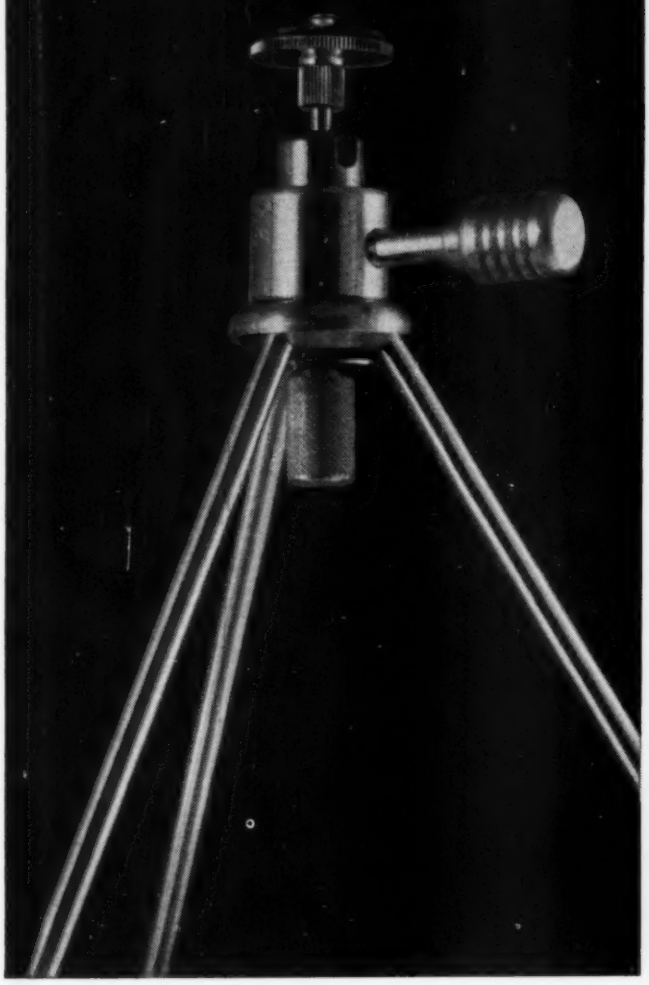
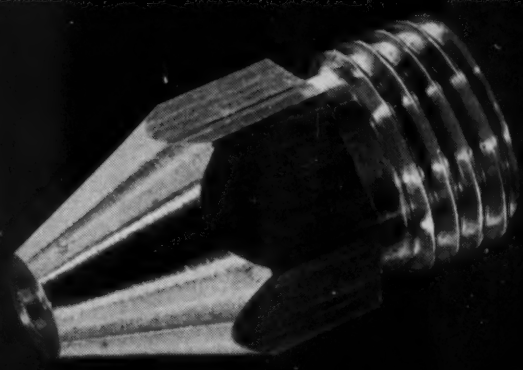
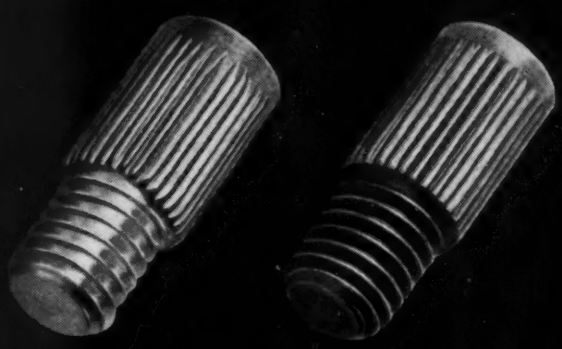




25.6% saved on this nozzle by using Kaiser Aluminum stock instead of brass.



35% saved on this swivel by using Kaiser Aluminum stock instead of steel.

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(*Continued from Page 21*)

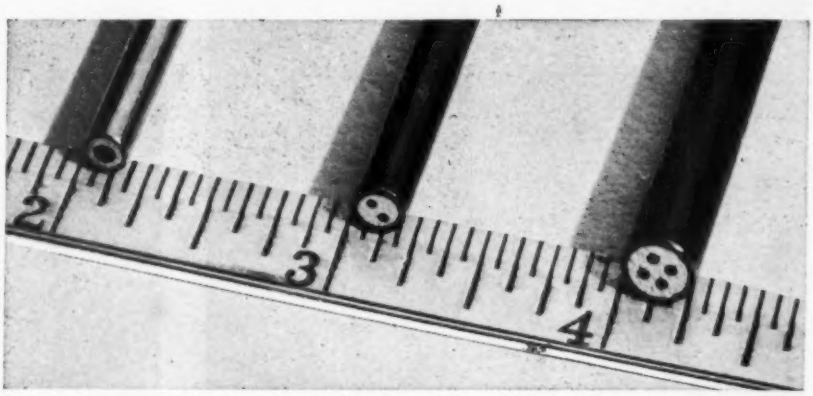
New Tool Material Will Speed Machining Time

Oxide-Base Material Promises Fast Cutting Tools

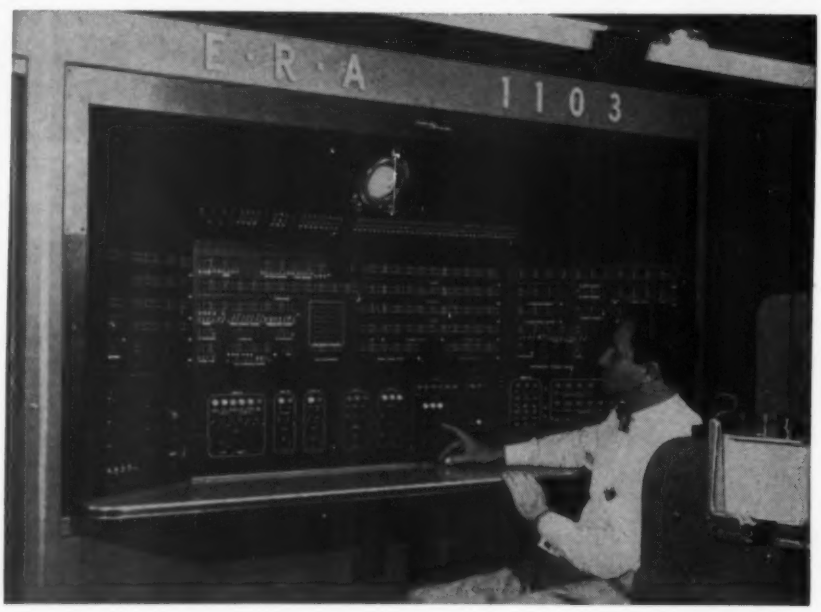
DETROIT, MICH.—Development of a new cutting-tool material is about completed, according to Carboloy Dept. of General Electric Co. Using a cemented-oxide base, the material is said to possess good tool life at speeds up to 2000 fpm. For example, at a feed of 0.005-inch and depth of cut of 0.1-inch at the 2000 fpm speed, the tool will last 27 minutes machining 1045 steel annealed to 170 brinell.

Lower tooling costs along with longer life are expected possible with the new development. Relatively inexpensive materials make up the new cutting tools as compared to tantalum, tungsten and cobalt used in many present high-speed cutting tools.

Still in laboratory stages, the new material is expected to undergo considerable field testing to determine its ultimate degree of usefulness. Because the new cemented oxide-base material is brittle, it is more susceptible to cracking than carbides. According to General Electric engineers, many of its properties must be thoroughly understood by the tool designer to take advantage of its full capabilities.



HIGH-TEMPERATURE CABLES, a development of Ferrod Mfg. Co., are designed to operate at temperatures up to 2000 F. Insulating material is crystalline magnesium oxide and the outside casing is a heat-resistant alloy. Available with up to six conductors, the cables are made in lengths up to 15 ft. Smallest diameter is 1/8-in.



FLASHING LIGHTS on the control panel tell the operator of this Remington-Rand ERA-1103 digital computer that his problem is being solved. One of the largest computers in the country, this unit was recently installed at the San Diego plant of Convair. This machine is said capable of remembering 17,408 individual sets of figures at one time, and can multiply ten-digit numbers at 2000 times a second

New Searchlight Features Quick Starting

Mercury-Xenon Lamp Unit Made for Navy Signalling

PITTSBURGH, PA.—New quick-starting lights developed for Navy searchlight use are eight times brighter than present signalling searchlights. Developed by Westinghouse Electric Corp., the units are rated at 1000 watts and produce about 3 million beam candlepower.

Tungsten electrodes are spaced about 1/4-inch apart inside a 2-inch diameter quartz bulb. An internal platinum heat reflector redirects and concentrates a certain amount of heat radiation within the xenon-filled bulb.

Upon application of power, the xenon permits an arc to be formed that produces light immediately. As the arc generates heat, the mercury is heated to a temperature at which it vaporizes and the lamp operates as a mercury arc source.

Small in size, the lamps require virtually no maintenance, according to Westinghouse. Operating life

for

HIGH TEMPERATURE PROTECTION

connect with cannon!

At aircraft firewalls... and wherever high temperatures are involved... you can get protection by using Cannon Steel Shell High Temperature Connectors to protect your electrical circuits.

Cannon made the first multi-contact firewall and high-temperature connectors... and is still the leader in the field with the greatest variety of fireproof connectors available today.

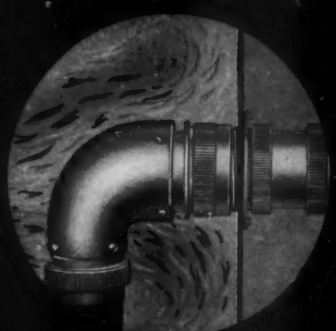
Cannon Fireproof AN-"K" Connectors effectively block dangerous fire paths by preventing passage of open flame at 2000° F. for at least 20 minutes... and maintain electrical circuitry during that time to meet military specifications.

Other Cannon firewall type connectors... the AN-"FW" and K-"FW"... block fire paths for 5 minutes at 2000° F., but circuitry is not necessarily maintained. A third application, not designed for firewall use, withstands 500° F. continuous heat and maintains circuitry. Hermetically sealed connectors are adaptable to this application.

Cannon High Temperature Steel Shell Connectors are used in general industrial applications. Combinations of various parts can be made to suit many high temperature applications. Inserts of glass-filled or asbestos-filled material. Wall- or box-mounting receptacles. Straight or angle 90° plugs. Solderless crimp-on contacts available. Consult our factory, giving temperature and circuit requirements.

K-FW Series

AN-K SERIES



SINCE 1915 CANNON ELECTRIC

first in connectors

CANNON PLUGS

Please refer to Dept. 185

CANNON ELECTRIC COMPANY, 3209 Humboldt Street, Los Angeles 31, California

Factories in Los Angeles, East Haven, Toronto, Canada, London, England. Representatives and distributors in all principal cities.

News Roundup

is said to be unusually long for this type of light source.

Transistor Control Protects Press Operators

Antirepeat Device Eliminates Moving Parts

CLEVELAND, O. — Failures of air-operated punch-press safety devices are expected to be minimized with a newly developed transistor-type antirepeat circuit. Necessary switching functions are accomplished by transistors instead of relays. Since transistors have no moving parts, extended service life of the control is foreseen by its designers.

Clark Controller Co. has designed and developed the unit in conjunction with a complete punch press safety system. Because press operators have found ways of bypassing safety features for the sake of fast operation, this system was designed to stop the press upon any attempt to outguess the safety devices.

Air control valves designed for the unit are fail safe. A series of self-checking features are built in to verify normal operation at each press stroke. Unless everything is working properly, the press stops. If the safety unit stops the press, it locks and cannot be reset until the fault is corrected.

In operation, the pressman is required to push two buttons, one with each hand. As is normal practice, the buttons are located so that both hands are well away from the business end of the press. The new control requires that both buttons be held until the press is near the bottom of its stroke. Both buttons must be released and pressed again before the machine will go into another cycle. This antirepeat feature is governed by the new transistor circuit. Relay type antirepeat units are also available. However, the company expects the transistor units to require less maintenance and adjustment.

Environmental Equipment Institute has announced a new quarterly for furthering the inter-

change of information among users of environmental equipment. Included in this group are laboratory and production personnel concerned with high and low-temperature, altitude, humidity, salt-spray, and similar environmental testing.

"I'll say one thing for Sam, when he puts in a line, he puts it in to stay!"

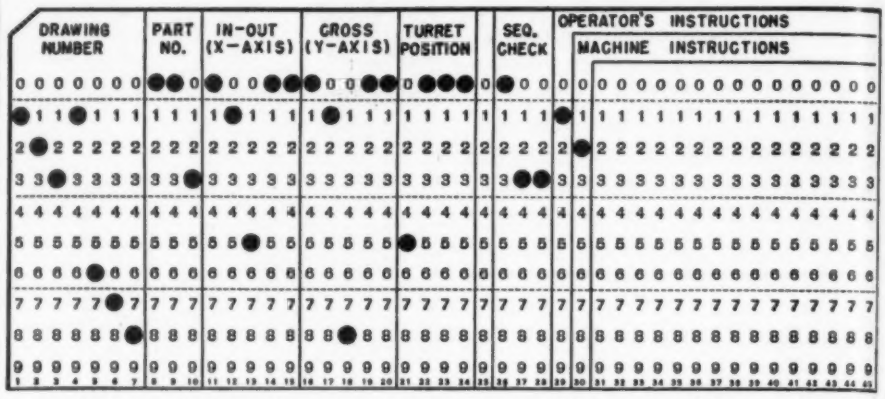
Holes Control Machine Tools

Punched Cards Give Positioning Directions

SCHENECTADY, N. Y. — Punched business-machine cards are used in a new automatic machine control. Recently announced by General Electric Co., the system is said to be readily adaptable for use with a wide variety of machine tools. Some applications include milling, drilling and boring machines, punch presses, lathes and shears.

Business-machine cards are processed, using standard card-processing equipment. Positioning information is punched into the cards in decimal form, but is not coded. The operator may read directions right from the card. Each card contains directions for one machining operation.

In operation, a group of cards representing the entire operation are placed in a "reader." As the first card is read, the machine positions itself accordingly and the machining operation takes place. The



A typical punched card used with the General Electric machine positioning control

next card is read while the first operation is under way. As soon as the first operation is completed, the machine automatically begins the next.

According to GE engineers, the big advantage of the punched-card system is that the operator can read instructions directly from the card. This is, of course, impossible with magnetic or specially punched plastic tapes. Greater flexibility of operation is also possible. Cards may be added for additional machining operations as required.

Direct-current motors on the machine are coupled to selsyn motors to indicate position. Lights on the control panel keep the operator informed of any special instructions.

Time-consuming jobs such as positioning templates and tools, laying out hole locations and hand checking are eliminated. Speed accuracy and length of motion may be selected individually for each application.

Control panel for the new General Electric Numerical Positioning Control. Punched business-Machine Cards control the operation of the machine tool

Magnetic Amplifier Smooths Generator Output

Mobile Unit Driven from Tractor or Truck Engines

BLOOMFIELD, N. J.—A self-regulated ac engine-driven generator has been developed for mobile power service. Driven from a tractor or truck engine, the unit is designed to supply ac power for farm equipment, water pumps and portable electric lighting.

To assure constant output, a magnetic-amplifier type voltage regulator has been designed to operate with the unit. Developed by Star-Kimble and Fidelity Electric Co., the regulator has no moving parts and is said to withstand rugged service conditions.

Need for an external rotating exciter is also eliminated by using selenium rectifiers. Exciter voltage is obtained by rectifying the ac generator output. It then builds up in the same manner as a self-excited dc generator.

Nominal operating speed of the generator is 3600 rpm. The machine is of two-pole design and will deliver 60 cps at the nominal

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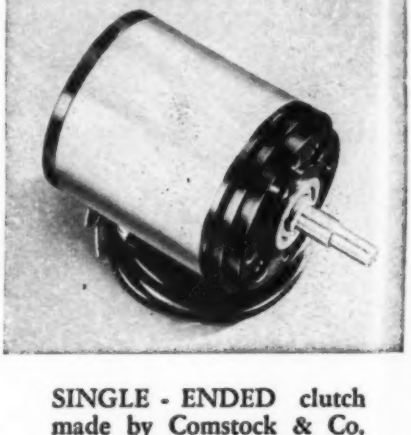
speed. Three units—3, 5 and 10 kw—are presently available.



SINGLE - ENDED clutch made by Comstock & Co. has both input and output shafts on one end of the unit. Concentric shafts allow the clutch to be mounted on a single hanger

Explosive Cylinders Pack Quick Punch

WILMINGTON, DEL.—Power cylinders that convert a small electrical signal to a relatively great mechanical force have been announced by Atlas Powder Co. The cylinders use a controlled explosive force to lift and momentarily hold various weights through a varied range of distances.

With lifting times measured in microseconds, they are adaptable to a variety of uses, such as remotely controlled safety and locking devices, opening or closing electrical circuits and ejection of equipment from aircraft or guided missiles.

One model, using a replaceable cartridge, will lift and momentarily hold a 100 lb weight through a distance of 2½ inches in an elapsed lifting time of 0.082-second. These power cylinders can be activated at will and require little or no maintenance.

Plastic-steel mixture developed by the Chemical Development Corp., is a combination of 80 per

cent steel powder and 20 per cent plastic. Called Devcon, the material can be worked like clay. After working it into the desired shape, the mixture is hardened by adding a special hardening agent. Total time for the hardening process is reported to be about two hours. No heat or pressure is required.

According to the company, items such as large dies and holding fixtures may be formed. The material is also recommended for filling holes in castings, bonding steel to itself or other metals, and building up worn surfaces.

AGMA Index (1947-49 = 100) shows volume for the gearing industry to be decreased by 5.7 per cent in June, 1955, as compared with May, 1955. The Index figure for June, 1955, is computed to be 193.5.

The AGMA Index for the first half of 1955 (January through June) is 173.5. This is an increase of 26.6 per cent over the last half of 1954 (July through December).

Pressed Metal Institute has announced the opening of a new headquarters building located at 3673 Lee Rd., Cleveland 20, O.

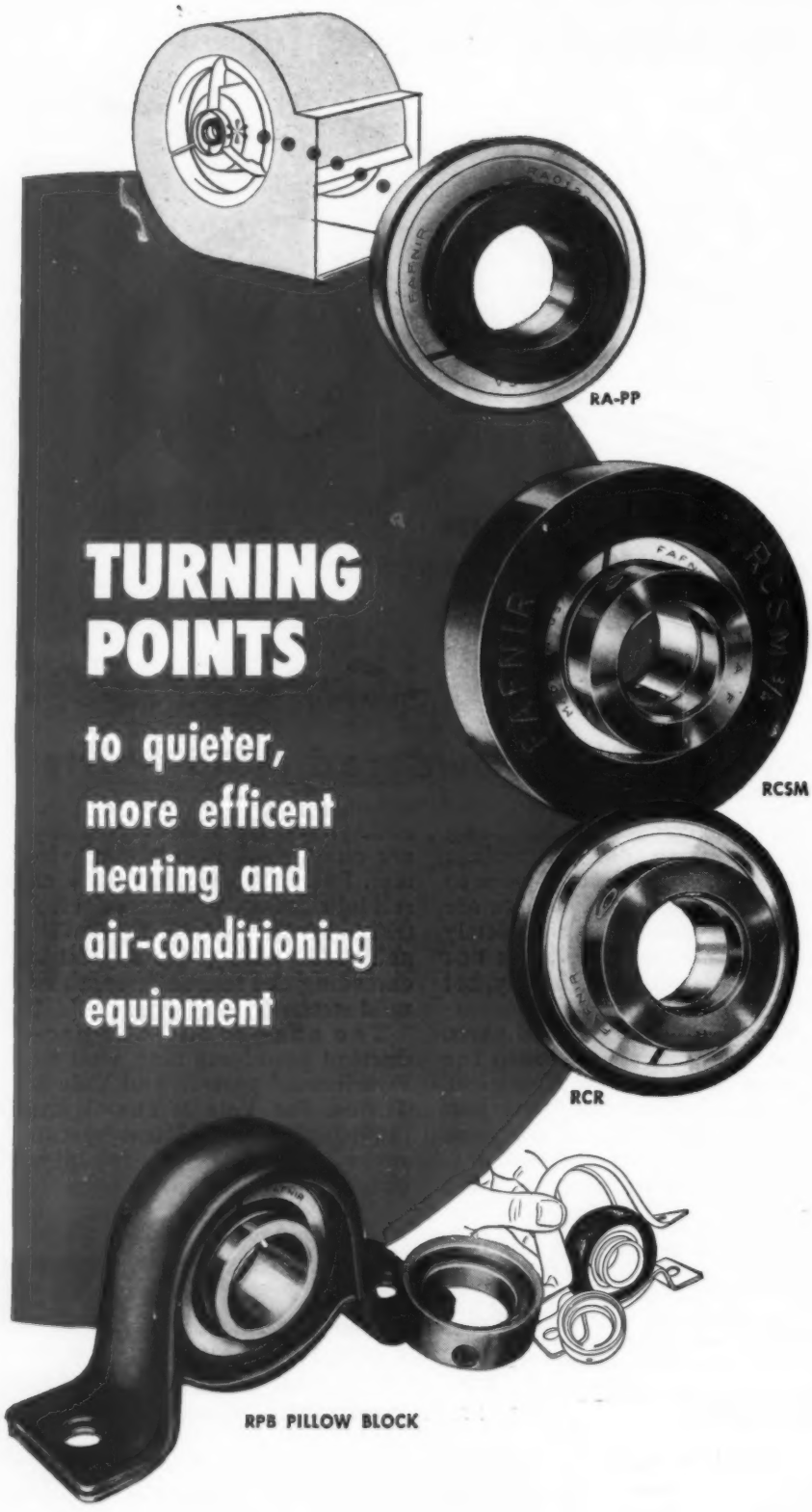
Huge Broach Makes Gears in a Hurry

One Pass Produces Gears Ready for Shaving

DETROIT, MICH. — Internal helical running gears for automatic transmissions are turned out in a single pass with a newly developed broach. Made by National Broach & Machine Co., the tool is about 7 ft long and weighs 700 lb. It is claimed to be the largest ever made for producing internal helical gears.

Tooth protuberances and tooth chamfering features are two design features of the unit. A special protuberance form provides clearance in the bottom of the gear tooth spaces for the shaving cutter. Inside-diameter gear-tooth edges are chamfered by the broach as it produces the teeth.

(*Continued on Page* 36)



TURNING POINTS

to quieter, more efficent heating and air-conditioning equipment

NEW SUPER-QUIET BALL BEARING SERIES

The RA-PP Ball Bearing Series, recent addition to the Fafnir Line, is specifically designed to take the place of ordinary sleeve bearings on equipment where quiet operation is of primary importance. Its construction features include:

1. *balls and races specially finished for super-quiet performance*
2. *sizes that fit popular bearing brackets using sleeve bearings*
3. *extended inner ring for greater shaft support*
4. *self-locking collar for easiest assembly . . . securely locks bearing to shaft with twist of wrist*
5. *patented removable Plya-Seals that positively keep dirt out, lubricant in*
6. *pre-lubricated with correct amount of long-life, factory-filtered grease. No relubrication needed.*

NEW RUBBER CYLINDRICAL CARTRIDGES

RCSM TYPE . . . specifically designed to be interchanged with other makes of ball bearing rubber-cushioned cartridges. Features new type super-quiet Fafnir Ball Bearing plus specially-developed electric current-conducting rubber cartridge.

RCR TYPE . . . specifically designed for interchanging with sleeve bearing mountings. Also features new type of super-quiet Fafnir Ball Bearing and specially-developed rubber cartridge.

NEW RPB TYPE RUBBER-CUSHIONED PILLOW BLOCK

A completely packaged low-cost ball bearing unit with engineered "super-quiet" construction, the RPB features (1) the new Fafnir super-quiet ball bearing, (2) a thick, electric-current-conducting rubber interliner, (3) compact, lightweight, two-piece pressed steel housing, (4) famous Fafnir self-locking collar making unit easiest of all to install, (5) patented Plya-Seals that retain prepacked lubricant for life and keep out contaminants.

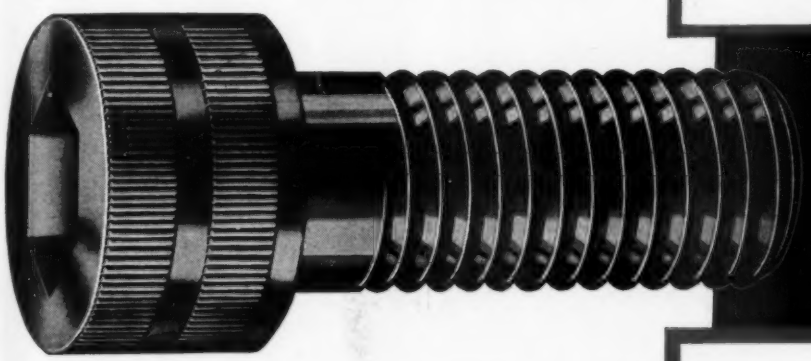
PLUS . . . a complete line of ball bearings with other types of rubber housings. **SEND FOR NEW BULLETIN,** The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

NO GADGETS-
NO GIMMICKS



SET SCREWS
For safety and high holding power.

BUTTON HEADS
Where countersinking is impractical.

CAP SCREWS
For high strength and compact design.

FLAT HEADS
For a smooth, unobstructed surface.

PIPE PLUGS
Precision threads for the tightest fit.

STRIPPER BOLTS
For concentric head, shoulder and thread.

DOWEL PINS
Special finish is corrosion-resistant, facilitates driving.

Holo-Krome Concentrates On Making Tough, Precision Socket Screws!

We offer the strongest, simplest, most accurate socket screws we can make!

For greatest strength and accuracy, we *completely* cold-forge the finest alloy steel. For maximum locking action, we thread to a Class 3 Fit.

When a socket screw is so carefully made . . . *it doesn't need any fancy "gadgets"!*

For the finest in socket screws . . . for SAME-DAY SERVICE ON STANDARD PRODUCTS . . . for cost-cutting packaging—the name to remember is HOLO-KROME!

Available from authorized Holo-Krome Distributors

HOLO-KROME

THE HOLO-KROME SCREW CORP. HARTFORD 10, CONN.

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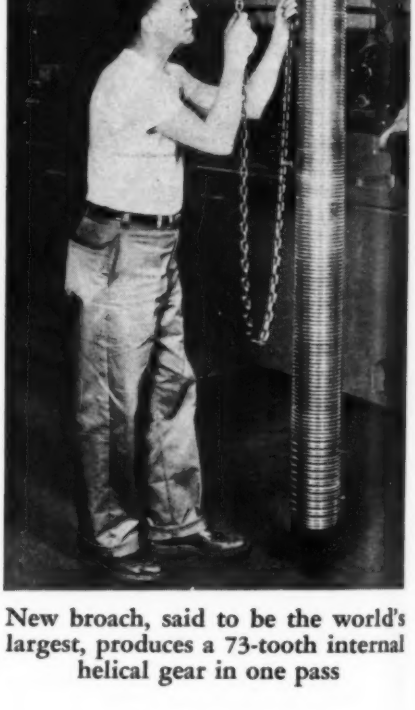
(Continued from Page 31)

Integral rings near the end of the broach finish the inside diameter. Thus, concentricity of outside diameter, inside diameter and sides of gear teeth is said assured.



New broach, said to be the world's largest, produces a 73-tooth internal helical gear in one pass

The internal-helical gear produced by the broach has 73 teeth, 14-pitch with 20 deg pressure angle. Helix angle of the gear is about 20 deg. All critical dimensions on the broach are held within 0.0002-in. tolerance.

Precision stamping directory, first ever compiled, is being published by the American Silver Co. The directory will be distributed free to companies who subcontract precision stamped parts or assemblies. The new publication lists precision job stamping sources in the United States.

Anaconda Wire & Cable Co. has started production of aluminum wire and cable in a new building at Sycamore, Ill. When operating at capacity, the new factory is ex-

pected to quadruple output of bare, rubber-insulated and synthetic-insulated aluminum wire and cable at Sycamore. Aluminum and copper production is carried on in separate locations to eliminate possible contamination of one metal by the other.

Square D Co. will begin construction immediately on a new plant to be located in Royal Oak, Mich., and has begun production at two recently completed units in Cedar Rapids, Ia., and Secaucus, N. J. With the Royal Oak plant scheduled for "substantial completion" in 1955, the combined new facilities will represent 250,000 sq ft of manufacturing floor space added this year, according to F. W. Magin, president.

Machines Respond to Magnetic Tape Orders

Entire Machining Program Recorded on One Tape

FOND DU LAC, WIS.—Duplication of complex machining operations is possible using an automatic system employing magnetic tape. Developed by Giddings & Lewis, the process has been applied to control a spar and skin milling machine. Called Numericord, the system may be adapted to control virtually any machine tool, according to company officials. Machining cycles involving as many as 5 machine axes and 22 auxiliary machine functions may be planned and fed into the device.

Five major components comprise the system:

1. Paper tape preparation unit
2. Electronic computing director
3. Magnetic tape recorder
4. Electronic play-back equipment
5. Electromechanical machine controls.

In preparing a series of operations, a paper tape is first punched in accordance with previously prepared information from engineering drawings, tooling data and machine feed rates. A special tape perforating machine simplifies the job.

Second step is to convert the information on the punched paper

News Roundup

tape into electrical signals. Electronic circuits in the computing director unit do this. Information from the paper tape is read by the computer and eventually finds its way on to magnetic recording tape. Fourteen channels on the magnetic tape hold all the necessary machining directions.

All 14 of the channels are read simultaneously on playback. Thus, a continuous stream of control signals are fed to the control circuits.

Machine axes are driven by dc motors connected through ballbearing nut and screw mechanisms. Auxiliary functions and nonfeed controls are operated through relay circuits controlled by impulses recorded on the tape.

One unusual feature of the system enables voice commands to be recorded on the tape along with the machine commands. In effect, the operator can be warned of tool changes or planned stops for machine inspection.

While the machine is operated on orders from previously prepared tapes, the process can be reversed. The machine control mechanism can be used to prepare its own tape. Machining cycles may be recorded from the machine axes synchros as they report tool travel. Models or templates control the tool head. Duplicate parts may be made by simply playing back the tape produced. Another method of making a control tape would be to let the operator put the machine through a simulated run.

Usefulness of the control system is most apparent when adapted to variable-axis, three-dimensional contouring machines. Any standard machine movement can be controlled. Among the shapes that can be cut are circles, parabolas, ellipses and spirals. In fact, any shape that can be mathematically defined in three-dimensional co-ordinates can be generated. Tolerances have proved to be well within the working limits of most machines.

Union Carbide Nuclear Co., a division of **Union Carbide and Carbon Corp.**, has been formed to integrate the corporation's activities in the atomic energy field. An objective of the new company will be

to carry on large-scale research and development in the industrial applications of atomic energy.

Reynolds Metals Co. plans to increase its primary aluminum producing capacity to 1.1 billion lb, Richard S. Reynolds Jr., president, has announced. Bulk of the expenditures for new facilities, about $200 million out of a total of $230 million, will be devoted to the 270 million lb expansion of primary producing and related facilities, including new bauxite mines in Haiti and Jamaica.

Titanium Sheet Stiffened By Contour Rolling

Three-D Patterns Add Stiffness With Same Weight

MIDLAND, PA.—Titanium sheet, Rem-Cru A-55 and A-70, have improved stiffness as a result of a contour rolling process developed by Rigidized Metals.

Use of unalloyed titanium sheet has resulted in weight savings in both military and civil aircraft. Certain applications have precluded use of aluminum because of high temperatures. Stainless steel, in some applications, adds too much weight. Since many aircraft applications require stiffness as well as strength and light weight, any improvement in stiffness of titanium is of importance to the designer.

Neither mechanical working heat treatment nor alloying can make a substantial improvement in the modulus of elasticity of titanium. However, rolling to a design-strengthening pattern has shown a substantial improvement in stiffness.

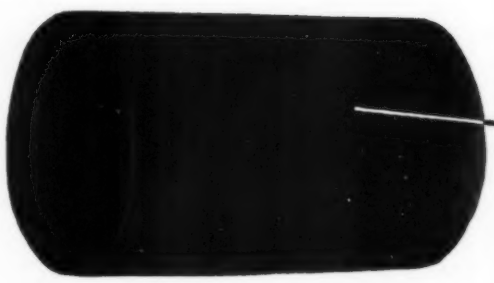
One example, a Rem-Cru A-70 sheet, 0.015-inch thick, showed a 27 per cent improvement in stiffness after rolling. The load-deflection curve after rolling was reported to be equivalent to an 0.027-inch thick A-70 sheet.

Sperry Corporation has been consolidated with **Remington Rand**

(*Continued on Page* 42)

GRAPHITAR® BUSHINGS IN VIKING

(CARBON-GRAPHITE)



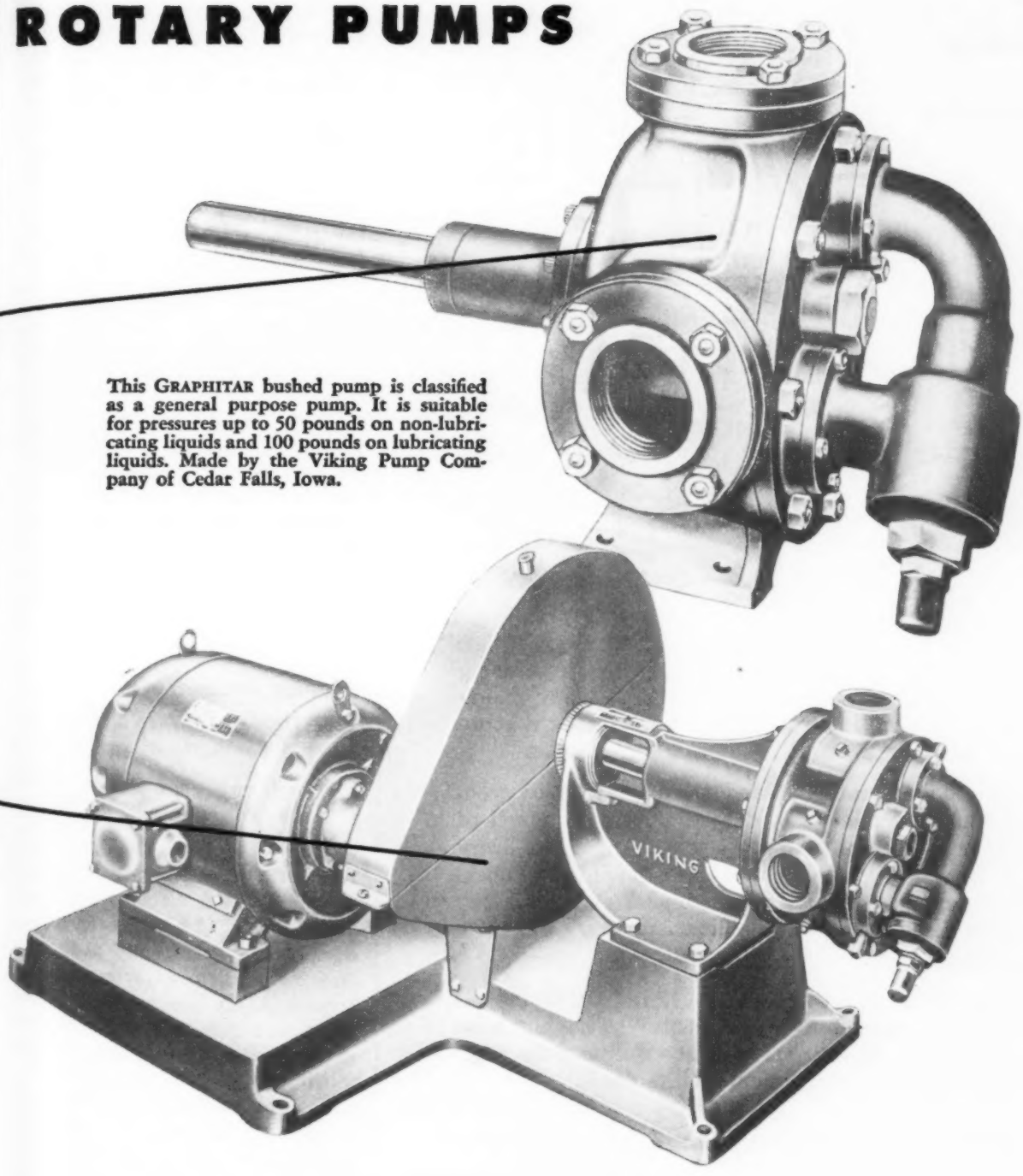
One of the features that accounts for the popularity of these two Viking rotary pumps is the fact that they require no outside lubrication of any kind. GRAPHITAR bushings make this possible. The only lubrication needed by the GRAPHITAR bushings is the liquid being pumped, (even LP-Gas). GRAPHITAR is compounded from carbon-graphite powders compacted under heavy pressure and furnaced at temperatures approaching 4500°F. Because of their composition and method of manufacture, GRAPHITAR parts are chemically inert (will withstand highly corrosive acids), will not warp and are extremely long-wearing. GRAPHITAR combines strength with lightness, and is virtually unaffected by high speeds or pressures or temperatures. It can be formed in relatively complex shapes and ground to tolerances as fine as .0005". In short, a really versatile engineering material. Write for our illustrated catalog.

OUR 101ST YEAR

THE UNITED STATES

NEED NO LUBRICATION

ROTARY PUMPS



This GRAPHITAR bushed pump is classified as a general purpose pump. It is suitable for pressures up to 50 pounds on non-lubricating liquids and 100 pounds on lubricating liquids. Made by the Viking Pump Company of Cedar Falls, Iowa.

The unusual properties of GRAPHITAR suit it well for use as bearing and mechanical seal in this Viking heavy-duty pump capable of handling 100 pounds pressure on non-lubricating liquids and 200 pounds on lubricating liquids.

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GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

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(*Continued from Page* 39)

Inc. to form **Sperry Rand Corp.** The business formerly conducted by Ford Instrument Co. Div. of Sperry Corp. will continue to be operated as heretofore, but as a division of Sperry Rand Corp.

Thomas & Skinner Inc. is the new corporate name of **Thomas & Skinner Steel Products Inc.** The company is engaged in the design, manufacture and commercial application of permanent magnets, electrical stamped-steel laminations and tape-wound cores.

American Wheelabrator & Equipment Corp. announces that it has changed its corporate name to **Wheelabrator Corp.**

H. K. Porter Co. Inc., Pittsburgh, has purchased Vulcan Crucible Steel Co., Aliquippa, Pa.

Heiland Div. of Minneapolis-Honeywell Regulator Co. has announced plans for a $1 million manufacturing plant in Denver, Colo.

Planned Accidents Test Reactor Safety

Experiments Show Steam Checks Power Rise

LEMONT, ILL.—Engineers at Argonne National Laboratories violently concluded a series of recent safety experiments by purposely destroying their experimental reactor. Before destruction, the reactor was put through over 200 safety tests to determine what might happen if it got out of control. Analysis of the results indicates that a properly designed water-cooled and moderated reactor will automatically shut itself down before high temperatures cause its destruction.

The experimental reactor was constructed at the AEC National Reactor Testing Station in Idaho. It consisted of a core assembly of plates made of enriched uranium and alumium immersed in water. All this was placed inside a steel tank.

Basis of the experiments was to cause the unit to go out of control by quickly removing the neutron-absorbing control rods. In the experimental setup, the reactor was operated at low power with all but one control rod removed. The last rod was removed suddenly and reactor power was allowed to rise.

Engineers found that the reactor would produce sufficient steam to check the rise of power. In fact, the steam produced reduced the power to a low level. Effectiveness of steam as a safety device depends upon the speed with which it is generated.

In early experiments, AEC researchers found that reactor power could be increased 10 times in about 0.05-second. By adjustment of the control rods, the rate at which power increases could be made more rapid. Further experiments were conducted in which power was increased 10 times in 0.01-second. Water was thrown from the tank to a height of about 30 ft. Fuel plates were deformed but did not melt.

Climax of the series of tests was reached when engineers decided to run an experiment that would melt the fuel plates. Ejection of the control rod was in about 0.2-second. Peak power was reached by the time the rod was 80 per cent out of the core. Maximum power reached was in excess of 10 million kw.

The explosion carried away the entire superstructure of the reactor which included the control-rod mechanism. Most of the fuel plates had melted and the open reactor tank had burst.

Fuel element fragments generally fell within a radius of 200 ft around the reactor. There was no appreciable radioactive fallout at distances greater than a few hundred feet.

Although the reactor was destroyed, the explosion was relatively mild compared to that which could be produced by a few pounds of TNT. Conclusion by engineers running the tests is that a catastrophic release of energy is prevented by inherently safe characteristics of the reactor.

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American Society for Testing Materials has elected Claire H. Fellows, director, Engineering Laboratory and Research Dept., Detroit Edison Co., president for 1955-56.

Engineering Psychology Section has been created at the Franklin Institute Laboratories. The new section will be part of the Electrical Engineering Div.

Budd Co. Inc. has assumed ownership and management of Continental-Diamond-Fibre Co. Included in the sale were plants in Newark, Del., Bridgeport, Pa., Valparaiso, Ind., and Spartanburg, S. C., and subsidiaries in Canada and France.

Piasecki Aircraft Corp. has been formed by Frank N. Piasecki, founder of the Piasecki Helicopter Corp., Morton, Pa. The new firm will be engaged primarily in the development of new aeronautical products.

American Brass Co, has broken ground at Mattoon, Ill., for a plant to manufacture flexible metal hose and tubing. The $2.5 million plant is expected to be ready for operation by January, 1956.

Meetings

AND EXPOSITIONS

Sept. 26-29—

Association of Iron and Steel Engineers. Annual Convention to be held at the Sherman Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Sept. 28-29—

Industrial Electronics Conference to be held at Rackham Memorial Auditorium, Detroit, Mich. Sponsored by the American Institute of Electrical Engineers and the Institute of Radio Engineers. Additional information may be obtained

from the American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.

Sept. 29-Oct. 1—

Standards Engineers Society. Annual Meeting to be held at Hotel Statler, Hartford, Conn. Additional information may be obtained from Arnold B. White, Program Chairman, c/o Veeder-Root Inc., Hartford, Conn.

Oct. 3-5—

National Electronics Conference to be held at Hotel Sherman, Chicago, Ill. Sponsored by the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University and the University of Illinois. Additional information may be obtained from J. Kocik, Publicity Committee Chairman, c/o Illinois Bell Telephone Co., 208 W. Westington St., Room 300, Chicago 6, Ill.

Oct. 3-7—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 33 West 39th St., New York 18, N. Y.

Oct. 5-9—

World Plastics Fair and Trade Exposition to be held at National Guard Armory, Los Angeles, Calif. Additional information may be obtained from Philip M. Kent, Managing Director, 700 Exposition Blvd., Los Angeles 7, Calif.

Oct. 6-8—

Society of Industrial Designers. Eleventh Annual Meeting and Design Conference to be held at The Woodner Hotel, Washington, D.C. Additional information may be obtained from society headquarters, 48 East 49th St., New York 17, N. Y.

Oct. 10-12—

American Society of Lubrication Engineers. Second Joint Lubrication Conference sponsored by ASLE-ASME to be held at the

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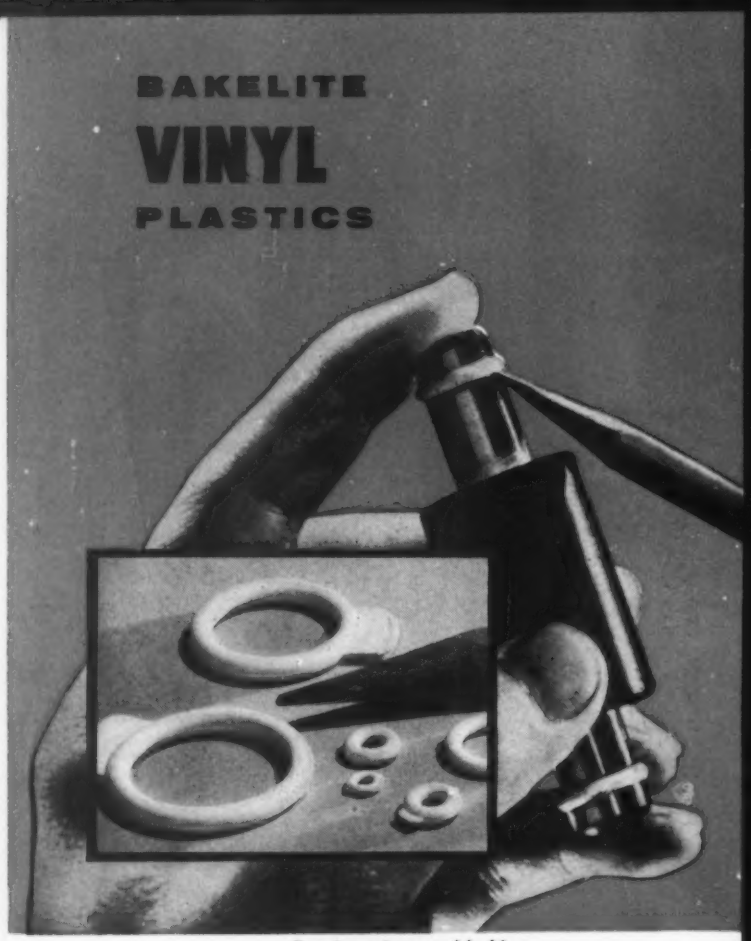
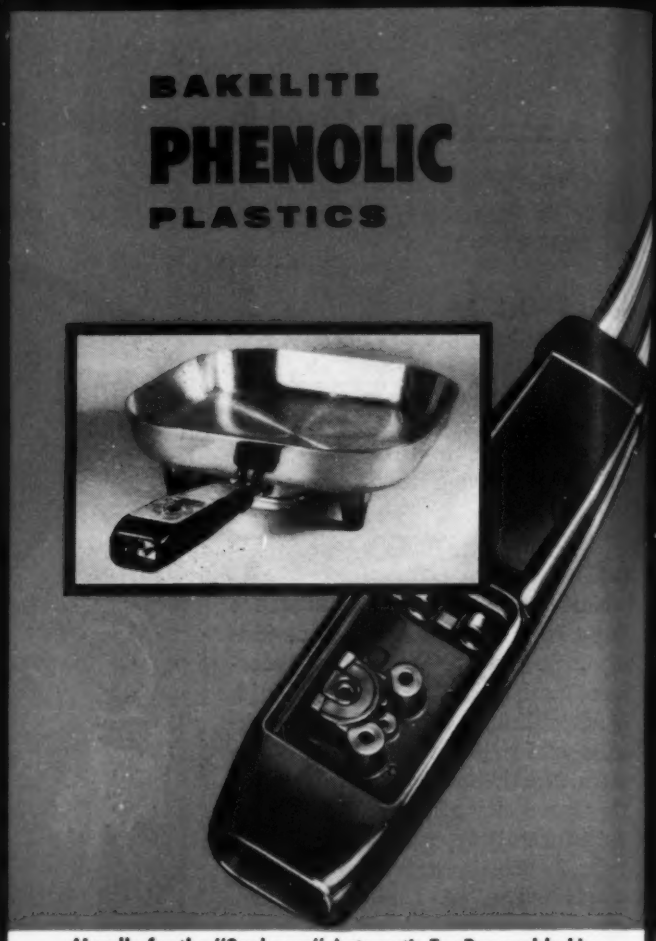


Retainer rings molded by
Shakeproof Division, Illinois Tool Works, Chicago 39, Ill.

These retainer rings call for a tough material. They fit into grooves on the ends of revolving shafts and keep wheels and bearings from slipping off. That's why they're molded from BAKELITE Brand Vinyl Plastic.

Their elasticity makes them easy to install or remove, gives them a tight grip in the groove. Air hammer vibration tests and cycle tests on solenoid arms, performed by the manufacturer, prove that they withstand 10,000,000 operations—100 times better than a cotter pin, 10-20 times better than a metal snap-ring.

BAKELITE Vinyl Plastics are resistant to oils, grease, water, and most chemicals. They offer great fidelity of mold detail, even for tiny pieces like these.



Handle for the "Sunbeam" Automatic Fry Pan molded by
Chicago Molded Products Corp., Chicago 51, Ill.

The handle for this automatic fry pan also houses the control element, so it requires a material that combines good appearance with superior molding qualities.

BAKELITE Brand Phenolic BMG-5000 Black 25 meets all the requirements. The big, comfortable handle has a rich black color and gleaming finish. It's molded with precise inner details to fit the delicate control mechanism. The stainless steel tubes are molded in for a watertight seal; the pan can be safely immersed in water up to the control element.

Durability and heat insulation were also important considerations in the selection of BMG-5000 Black 25. The handle is as functional as it is handsome.

BAKELITE

TRADE-MARK

GREATEST VARIETY, LARGEST RESOURCES FOR PLASTICS KEYED TO YOUR NEEDS

The success of a plastic product is based on selection of the right material. Bakelite Company helps you meet this problem in several ways. Here is a single source of supply for plastics and resins that have widest application. Plants and warehouses are strategically located for prompt delivery and service. And you can call on Bakelite Company technical representatives for guidance. They are backed by extensive research and development facilities and by Bakelite Company's 45 years of experience in the plastics industry. Write Dept. GS-103.

BAKELITE

STYRENE

PLASTICS

"Linex" Stereo Viewer made by
Linex Division of the Lionel Corp., Irvington, N. J.

A stereo viewer takes a lot of handling when slides are changed and it's passed around. Sometimes it's taken apart to change bulbs or batteries. In addition, it has to have a quality appearance.

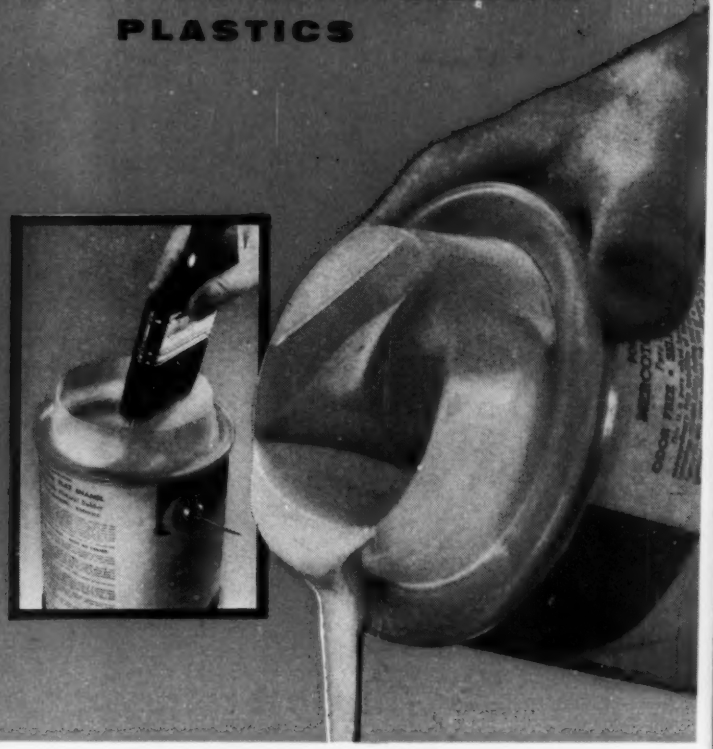
That's why this one is molded from BAKELITE Brand High-Impact Styrene TMD-5151. This material is tough, dimensionally stable, and resistant to warping and shrinking. Sections form a clean, tight fit. The viewer also has a soft matte finish that always looks attractive.

The high plasticity of TMD-5151 results in the fastest set-up speed available in a high-impact styrene –another reason why it's so popular with molders.

BAKELITE

POLYETHYLENE

PLASTICS



"Nomus" paint can top molded by
Rainbow Plastic Products Co., Minneapolis 16, Minn.

Molding this paint can collar of BAKELITE Brand Polyethylene provides several practical benefits. Inherent flexibility makes it easy to attach or remove. Accurate molding assures a tight fit. Paint won't harm it.

Molded for either quart or gallon sizes, the collar seals the can edge, keeps paint from running down sides or getting into the lid groove. It even has a brush-wipe molded in—another plus for neatness.

BAKELITE Polyethylene, the lightest commercial plastic, is excellent for many jobs requiring toughness and high mechanical strength, even with unusual shapes. It can also be given a wide range of colors and has outstanding dielectric properites.

BAKELITE
BRAND
PLASTICS

PHENOLICS • STYRENES • IMPACT STYRENES
POLYETHYLENES • VINYLS • POLYESTERS
EPOXIES

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.
In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario
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News Roundup

(*Continued from Page* 45)

Antlers Hotel, Indianapolis, Ind. Additional information may be obtained from society headquarters, 84 E. Randolph St., Chicago 1, Ill.

Oct. 11-15—

Society of Automotive Engineers. Aeronautic Meeting, Aircraft Production Forum and Aircraft Engineering Display to be held at Hotel Statler, Los Angeles, Calif. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Oct. 14-15—

National Society of Professional Engineers. Fall meeting to be held at the Peabody Hotel, Memphis, Tenn. Additional information may be obtained from society headquarters, 1121 15th St., N.W., Washington 5, D.C.

Oct. 17-21—

National Metal Congress and Exposition to be held at Commercial Museum and Convention Halls, Philadelphia, Pa. Sponsored by the American Society for Metals. Additional information may be obtained from society headquarters, 7301 Euclid Ave., Cleveland 3, O.

Oct. 19-21—

Gray Iron Founders' Society. Annual Meeting to be held at Hotel Schroeder, Milwaukee, Wis. Additional information may be obtained from society headquarters, National City-East Sixth Bldg., Cleveland 14, O.

Oct. 23-26—

American Gear Manufacturers Association. Semiannual Meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, One Thomas Circle, Washington 5, D.C.

Oct. 24-25—

Steel Founders' Society of America. Fall Meeting to be held at The Greenbrier, White Sulphur Springs, W. Va. Secretary is George K. Dreher, 606 Terminal Tower, Cleveland 13, O.

Oct. 24-26—

American Standards Association.

Thirty-seventh Annual Meeting in conjunction with the Sixth National Conference on Standards to be held at the Sheraton-Park Hotel, Washington, D.C. Sponsored by ASA and the National Bureau of Standards. Additional information may be obtained from society headquarters, 70 East 45th St., New York 17, N. Y.

Oct. 25-27—

American Institute of Electrical Engineers. Aircraft Electrical Equipment Conference to be held at the Hollywood Roosevelt Hotel, Los Angeles, Calif. Additional information may be obtained from society headquarters, 33 West 39th St., New York 18, N. Y.

Oct. 27-28—

National Conference on Industrial Hydraulics. Eleventh Annual Meeting to be held at the LaSalle Hotel, Chicago, Ill. Sponsored by the Illinois Institute of Technology and Armour Research Foundation in co-operation with engineering societies and industrial organizations. Additional information may be obtained from C. A. Arents, Secretary, Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Oct. 31-Nov. 1—

Magnesium Association. Annual Meeting to be held at the Biltmore Hotel, New York, N. Y. Additional information may be obtained from society headquarters, 122 East 42nd St., New York 17, N. Y.

Oct. 31-Nov. 1—

Scientific Conference on Solar Energy to be held at the University of Arizona, Tucson, Arizona. Additional information may be obtained from the Public Relations Dept., Stanford Research Institute, Stanford, Calif.

Nov. 1-5—

World Symposium on Applied Solar Energy to be held at the Westward Ho Hotel, Phoenix, Arizona. Sponsored by Stanford Research Institute, the Association for Applied Solar Energy and the University of Arizona. Additional information may be obtained from

Engineering News Roundup

the Public Relations Dept., Stanford Research Institute, Stanford, Calif.

Oct. 31-Nov. 2—

Society of Automotive Engineers. Transportation Meeting to be held at The Chase Hotel, St. Louis, Mo. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Nov. 1-3—

Investment Casting Institute. Fall Meeting to be held at the Sheraton-Cadillac Hotel, Detroit, Mich. Additional information may be obtained from society headquarters, 27 East Monroe St., Chicago 3, Ill.

Nov. 2-4—

National Fluid Power Association. Fall Meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from Barrett Rogers, Executive Secretary, 1618 Orrington Ave., Evanston, Ill.

Nov. 2-4—

Society of Automotive Engineers. Diesel Engine Meeting to be held at The Chase Hotel, St. Louis, Mo. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Nov. 9-10—

Society of Automotive Engineers. Fuels and Lubricants Meeting to be held at The Bellevue-Stratford, Philadelphia, Pa. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Nov. 13-18—

American Society of Mechanical Engineers. Diamond Jubilee Annual Meeting to held at Hotel Congress, Chicago, Ill. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Nov. 14-18—

Chicago Exposition of Power & Mechanical Engineering to be held at the Chicago Coliseum. Under the auspices of the ASME as part of the Diamond Jubilee Meeting. Additional information may be obtained from E. K. Stearns, Exposition Manager, International Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Nov. 14-17—

Second International Automation Exposition to be held at the Navy Pier, Chicago, Ill. Additional information may be obtained from Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa.

Nov. 17-18—

American Society for Quality Control. Tenth Mid-West Conference to be held at Hotel Schroeder, Milwaukee 1, Wis. Additional information may be obtained from P.O. Box 1204, Milwaukee 1, Wis.

Dec. 10-16—

International Atomic Exposition to be held at the Public Auditorium, Cleveland, O. Sponsored by the American Institute of Chemical Engineers. Additional information may be obtained from Athel F. Denham, Director, 931 Book Bldg., Detroit 26, Mich.

Dec. 12-16—

Nuclear Engineering & Science Congress to be held at the Public Auditorium, Cleveland, O. Additional information may be obtained from the Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

Dec. 11-14—

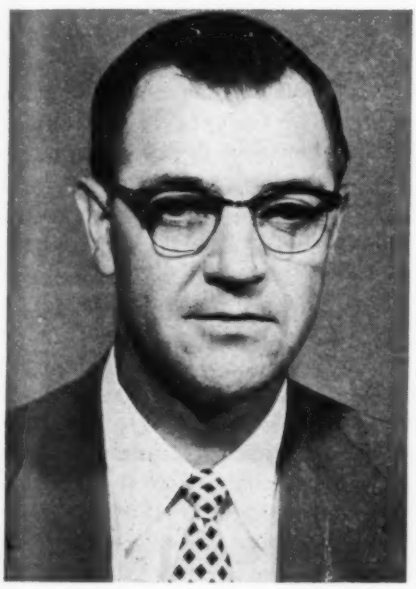
American Society of Agricultural Engineers. Winter Meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from Frank B. Lanham, Secretary, St. Joseph, Mich.

May 24-25, 1956—

Third Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind., sponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information may be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

MEN
OF MACHINES

Colonial Broach and Machine Co., Detroit, has announced the appointment of **George Cameron** as



George Cameron

director of engineering and **Gordon Cook** as supervisor of broach engineering. Mr. Cameron was co-owner of Cameron and White Co., a Detroit engineering firm, before joining Colonial. Prior to that he was assistant chief engineer for the radar and gear division of the Palmer-Bee Co. He is a member of the Engineering Society of Detroit. Mr. Cameron was educated at Fenn College in Cleveland.

Mr. Cook, who has been a broach engineer since 1946, is a graduate of Lawrence Institute of Technology in Detroit.

Robert T. Schultz has been appointed chief engineer of the Electronics Div. of Nader Mfg. Co., Monrovia, Calif. Previously Mr. Schultz was a member of the technical staff of Hughes Aircraft Co., Culver City, Calif.

Jack & Heintz Inc., Cleveland, has appointed **Ralph J. Eschborn** to the position of chief engineer. Mr. Eschborn, who has had more than 15 years of experience in the research, design and production of aircraft engines and accessories, joined the company in 1951 as a staff engineer. A year later he was named engineering executive manager, and since 1953 he has served as assistant chief engineer. Prior to joining Jack & Heintz, Mr. Eschborn was an aeronautical research scientist with the Lewis Flight Propulsion Laboratory of the NACA. Earlier, he was assistant director of the Aeronautical Research Laboratory at the University of Kentucky, where he had received his B.S. degree in mechanical engineering. He earned a master's degree in aeronautical engineering from Case Institute of Technology. Mr. Eschborn is a member of the Institute of Aeronautical Sciences, the American Institute of Electrical Engineers, the Society of Automotive Engineers,

Ralph J. Eschborn

Men of Machines

the Cleveland Engineering Society, Tau Beta Pi and Sigma Pi Sigma.

The appointment of **Joseph B. Bidwell** as head of the engineering mechanics department has been announced by General Motors Corp., Detroit. Mr. Bidwell succeeds **Robert Schilling,** who recently was named director of research and development in the engineering department of the Chevrolet Motor Div.

A new division has been established by Studebaker - Packard Corp., Detroit, to co-ordinate all government and industrial product programs. **George H. Brodie** has been named vice president and general manager of the division and will direct all activities, including engineering. Product research programs will be carried out under the direction of **William Bollay. O. E. Rodgers** has been appointed assistant general manager and chief engineer.

The election of **Kenneth R. Herman** as president and **N. E. Edlefsen** as vice president of engineering was announced recently by Vickers Inc., Detroit. Mr. Herman was formerly vice president and general manager of the company. Before joining Vickers in 1931 he had been associated with various organizations in the automotive

Kenneth R. Herman

N. E. Edlefsen

industry. He is presently secretary and chairman of the Detroit section of the Society of Automotive Engineers and is vice president and a director of the Engineering Society of Detroit. He is also a member of the American Ordnance Association, the American Society of Mechanical Engineers, the Institute of the Aeronautical Sciences and the National Security Industrial Association.

Dr. Edlefsen graduated from Utah State College and received M.A. and Ph.D. degrees in physics from the University of California at Berkeley. From 1947 until he joined Vickers, he was associated with North American Aviation Inc. His most recent assignment there was that of director of the electromechanical engineering department of the missile and control operation. Dr. Edlefsen is a member of the Institute of Radio Engineers, the American Physical Society, the Geophysical Union and the Association for Computing Machinery.

Robert E. Kessler has been named general manufacturing manager for the Technical Products Div. of Allen B. du Mont Laboratories Inc., Clifton, N. J. Mr. Kessler's responsibilities include supervision of the engineering department.

Allstates Engineering Co., Trenton, N. J., has appointed **Emery B. Kerekes** chief engineer. He will be responsible for all technical as-

Men of Machines

pects of the engineering, design and development activities of the firm. Mr. Kerekes, who was formerly associated with Loewy-Hydropress Inc., has had 28 years of experience in research, development, production consulting and management.

Maynard M. Boring was elected president of the American Society for Engineering Education at the society's recent annual meeting. Dr. Boring, who served for many years as manager of employment and training of engineering graduates at General Electric Co., retired from this position in August of last year to become the company's consultant on manpower.

Kellogg Div. of American Brake Shoe Co., Rochester, N. Y., has announced the appointment of **Cornell Janeway** as research engineer. He was formerly assistant chief engineer at Taub Engineering Co.

A. O. Schaefer will serve as president of the American Society for Metals for the year 1955-56, taking office during the 37th National Metal Congress and Exposition in October. Presently vice president of the society, Mr. Schaefer is vice president in charge of engineering and manufacturing of the Midvale Co., Philadelphia.

As a result of the recent election of **Walter J. Niles** as president of Kraus Automatic Machines Corp., Rochester, N. Y., **Charles E. Kraus** will now devote full attention to engineering and development. He has been acting as both administrative and engineering head of the concern.

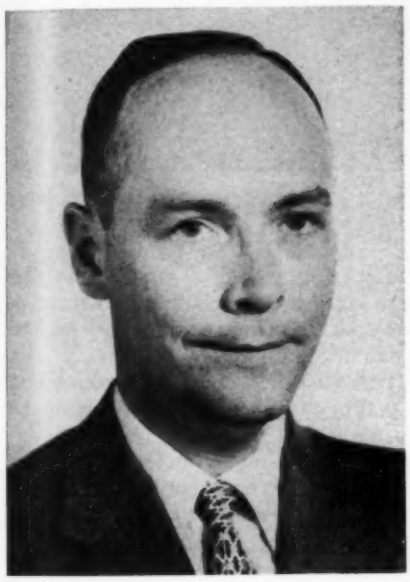
Robert C. Verhaeghe has been named chief engineer of the automotive division of Modine Mfg. Co., Racine, Wis.

D. R. Tashjian has been appointed manager of engineering of the electronics division of Westinghouse Electric Corp. in Baltimore. Mr. Tashjian joined the division in 1941 as a design engineer.

Westinghouse also has an-

nounced the appointment of **D. W. Berry** as assistant chief engineer for its aviation gas turbine division in Kansas City, Mo. Mr. Berry will retain his position as director of development.

Marquette Metal Products Co., Cleveland, has appointed **John L. Fuller** to the newly created position of director of engineering. He will have charge of all product engineering and quality control. Mr. Fuller had been associated with



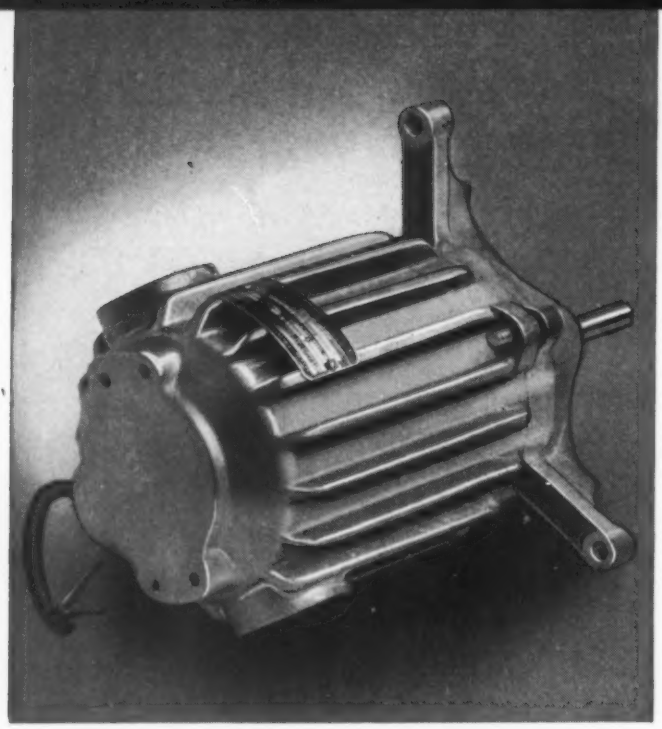
John L. Fuller

Reliance Electric & Engineering Co. for 19 years. Marquette also announced that **Jerry Gleitz** has been named manufacturing engineer. He will be concerned primarily with a program of cost reduction.

Charles F. Simmers has been appointed vice president in charge of engineering by Morgan Engineering Co., Alliance, O. He succeeds **William L. Ditges,** who retired July 1.

Steve **Toth** has joined Ford Motor Co. as project engineer in the Engine Engineering Dept. of the engineering staff. He has been senior designer for the General Motors Corp. Truck and Coach Div.

Adolf A. Widmann has been appointed vice president in charge of engineering of National Machine Products Co., Utica, Mich. He joined the company in 1927.



1. UNIVERSAL MOTOR FOR BLOWER MEETS LIMITED SPACE REQUIREMENTS

General Electric engineers were asked to supply a specially mounted motor for an axial fan. Among the special considerations were a limited amount of space for the motor and need for exceptionally long brush life.

The space problem was solved by G-E engineers with a universal motor designed with a special tripod mounting, extended bearing nose, and a diameter of only $6\frac{5}{16}$ inches. Extensive testing proved this motor to have more than required brush life. This General Electric air-over motor can also be supplied in Class 1, Group D, explosion-proof construction.

2. SPECIAL DC BRAKE MOTOR DESIGNED FOR LOCOMOTIVE DOOR OPENER

Limited space requirements presented a problem to G-E engineers when they were asked to design and build a motor to open and close a 1200-pound locomotive car door. Another specification: positive starting and stopping action.

A team of General Electric motor experts designed a special space-conserving, side-wall mounted motor to be used with a gear reducer and magnetic brake.

G.E. offers a complete line of d-c motors in the following enclosures: drip-proof, totally enclosed non-ventilated, explosion-proof, severe-duty, navy- and marine-type construction.

These four cases show how you

MACHINE DESIGN
SEPTEMBER 1955

A Hindrance to the Profession

WHEN we think of engineers as professionals, we are apt to compare our standing with that of doctors and lawyers. There are implications of high ideals and ethical standards but also overtones of exclusiveness and economic self-protection. To the public the picture is confusing and not too appealing.

Another way of looking at a professional is to contrast him with an amateur—the trained competence of the professional versus the dabbling of the amateur. Compare the performance of a top-notch professional musician or orchestra with that of amateurs—or a professional versus an amateur stage show. The rigorous self-discipline and single-minded dedication of the professional shine through every note or line. The public can quickly recognize and appreciate that kind of professionalism.

How many engineers are truly professional in this sense? How many, having taken advantage of rigorous training under acknowledged masters, have maintained their engineering competence at concert pitch? Or how many, having barely made the grade in college, are content with intellectual stagnation, completely out of tune with modern design techniques?

Let's face it. The acting profession has its hams, medicine has its quacks and engineering, alas, has its share of "hacks." The general public which pays the bill does not expect quack service from doctors or ham performance from actors. Likewise the engineer's public—management—does not expect a hack when it hires an engineer calling himself a professional.

The professional standing which engineers claim—and hope to have recognized and rewarded—can be jeopardized by too many hacks. Engineers striving for advancement have an obligation to insist on adequate standards of professional competence in their own ranks. They cannot afford to permit hacks or amateurs posing as professionals to hinder the progress—economic and otherwise—of their profession.

Colin Carmichael

EDITOR

Colleges and universities can be more than a source of trained manpower for industry. Through co-operative programs, schools can help companies maintain and improve competitive strength. Mutual understanding of needs and objectives is the first requisite of any venture in joining

PROFITS AND P

COMPETITION is a relentless taskmaster, and demands that every available resource be tapped. Technical resources often substantially determine the result. Men and facilities—scientists, engineers and technicians along with the essential technological paraphernalia of their trades—must be directed toward designs for tomorrow's products.

Among these resources are the colleges and universities of the country. Some companies enjoy a continuing profitable relationship with selected universities and colleges. Others are not so happy and are looking for help.

Engineering executives face the problem of effectively incorporating available college and university facilities into programs designed to strengthen competitive positions.

The problem

One corporation executive stated his problem in these words: "Lack of results has been our general experience in tapping the technical resources of universities and colleges." "We're going to drop educational institutions from future plans because they don't understand our problems," was a recent comment of the vice president of a major steel company.

Programs must be productive

Lack of results delivered in a businesslike manner prompted these complaints. Results are vitally important. Results are proof of performance. Engineers must look for results. Profits are based upon productive programs.

Overall experience with co-operative industry-university programs has not been as decidedly negative as that of the engineer quoted. Many corporations have participated in very profitable programs. A typical success story can be cited. One major electronics manufacturer has participated in a co-operative program with one of our leading engineering schools for over 20 years. This co-operative program quite probably will be able to celebrate its golden anniversary at a future date.

Programs mutually profitable to both industry and educational institutions must be deliberately constructed. A meeting of minds is important. The reasons will become apparent.

Problems must be recognized

Nothing is to be gained by adopting a closed-minded, competitively jealous attitude relative to the success others have had with co-operative industry-university programs. Rather than adopting such an attitude, alert managements scrutinize successful programs seeking guidance.

Mr. A should take a healthy interest in the more successful experiences of Mr. B and Mr. C. Mr. B and Mr. C should recognize this. Everyone stands to gain. Knowledge comes from the discovery of ignorance.

The concept of co-operative programs is relatively new. New programs always place added burdens on management. The remark that follows points up the existing conflict: "I took a problem to the college, but I did not get an answer I could use," an engineering executive complained. The professor's reply was, "We gave you the answer but you didn't use it." A familiar impasse resulted.

Both parties were right.

There is a way to avoid such an impasse. Experience is the teacher. Let's study the lesson. At the outset one must analyze the services made available to industry by the engineering and technical departments of colleges and universities.

PROFESSORS

By Philip R. Marvin

Consultant
Philadelphia, Pa.

Available services must be understood

Educational institutions provide industry with services that fit roughly into four groupings:

1. Educational institutions provide technically trained talent. This talent is needed by industry in steadily increasing numbers due to industrial expansion and the increasing complexity of industrial technology.
2. Specialized equipment and expert know-how are available.
3. Educational institutions are a storehouse of new ideas and methods.
4. Instructional talent is available for industrial training and development programs.

Engineer training: the primary job of engineering schools

The president of one of the leading engineering schools emphasized that the job of his faculty was to provide industry the trained manpower product needed. Engineering institutions are the training ground for industry. True, some engineering graduates go into academic spots, but these men are in a minority group and represent a vitally essential diversion of the flow of embryonic engineers.

Those in responsible positions in educational institutions recognize the training role. Other services to industry must be made subordinate to this primary role. Industry itself would be the first to suffer if educational institutions neglected this responsibility.

Industry does not always face this fact squarely. The following comment is typical. "We placed a development project with the mechanical department of the — — — University and it was three months before Professor — — — got going on it. Then the summer vacation came along and the student staff working on the project left for vacation."

Executives must recognize that the education of the student comes first. Vacations are part of the process.

Professors develop fundamentals: industry develops methods

Industry is ultimately concerned with products but it would be a practical impossibility to train engineers to know all of the design standards of each and every industrial operation. No individual engineering executive has such detailed knowledge at his personal command. Colleges and universities are primarily concerned with the development and dissemination of basic design fundamentals. Engineering training must concentrate around these basic relationships.

Engineering management too often holds the professor responsible for understanding the corporation's individual methods. A familiar comment is this: "Professor — — — spent six months on our project before we discovered that he was following an approach that was not consistent with our general product line. The trouble with these professors is that they are impractical. They don't understand our business."

It isn't the job of a professor to be as familiar with the engineering requirements of a corporation as those in positions of direct responsibility. The professor's job is to teach fundamentals to engineers-in-training. Engineering practices should be taught on the job. Engineering executives calling upon a professor to undertake a project should provide the professor with a complete picture of the limitations of the proposed product. The professor shouldn't be expected to know these.

In a number of situations, businessmen haven't understood their own product needs well enough

to state requirements and limitations clearly enough to enable sound product development. Blame placed on professors for impractical results often is the result of the engineering executive's lack of understanding of his own problem. This is frequently the real reason underlying lack of results or impractical results.

Specialization offers advantages and imposes penalties

Shrewd engineers capitalize upon the advantages of specialization by minimizing its penalties through teamwork. This concept forms the basis of effective use of university and college resources.

The background and experience of most engineers do not qualify them for academic responsibilities. In a similar respect, before they are at home in industry, professors must make substantial adjustments in their thinking and outlook.

Put the two together, the engineer's outlook and the professor's viewpoint, and you have a powerful competitive weapon. The professor concentrating on basic fundamentals and the engineer looking after end-use applications constitute power-packed teamwork.

Resources harnessed

Technical teamwork capitalizes on specialization. Teamwork is the basic ingredient in co-operative relationships between industry and the educational institution. It assumes a number of forms as it develops into a profitable relationship.

Aids to engineering training

Co-operative relationships with educational institutions should commence with clearly understood goals in mind. If the corporation wishes to aid the institution's training program, aid will be welcomed in a number of forms.

Outright grants of money provide the educational institution the greatest degree of flexibility in their operations. This flexibility is impaired to the degree that any such funds are earmarked for specific purposes.

Many corporations are in a position to make grants of equipment, equipment either of their own manufacture or purchased and given to the college or university. Engineering coursework imposes severe strains on budgets because of equipment requirements. Industry helps the school by such grants, and in turn will get better trained engineers as a by-product.

Industry can loan manpower to the schools, too. Short courses taught by industry personnel are valuable in rounding out the curriculum and injecting greater perspective of viewpoint into educational programs.

In addition to grants of money, equipment and manpower, industry can make substantial contributions in the way of co-operation with surveys and research studies made by the faculty and students of engineering schools.

A substantial portion of the raw data essential to many engineering research projects can be found only in industry. Both faculty and students need access to this data in order to develop better course material or as basic data for development of individual technical skill. Full co-operation by industry with thesis projects, research studies, symposia and conferences will substantially aid engineering training. Summer employment of both students and faculty in industrial plants and laboratories is also extremely helpful to the technical school.

None of these aids to engineering training represent assistance that moves down a one-way street. Direct and indirect returns to industry will accrue from each, but the primary objectives of the assistance should be recognized to be that of aiding the engineering schools in their function of turning out better engineers.

Project grants

Quite aside from its need for more and better engineers, every corporation is faced with a certain number of problems that need to be solved. Corporations are often looking for outside help in solving these problems. Engineering schools can solve these problems in many cases.

A fundamental distinguishing characteristic differentiates the project grant from aid-to-training. This aspect should be clearly understood. A project grant is made for the purpose of getting a problem solved. Every other consideration is subordinate to this requirement.

Project grants call for a clearly defined problem. The problem should be developed by company personnel familiar with its nature in terms that state first, second and third order requirements and limitations. In addition the expert personnel and special facilities needed to solve the problem should be determined, so far as possible in advance.

The project should be placed for execution where it has its best chance of successful solution within a time commensurate with cost. When project grants are placed with the dual purpose in mind of providing aid-to-training and getting a problem solved at the same time, a compromise element is introduced that commonly results in general dissatisfaction on the part of parties concerned.

Tests of any co-operative venture

Clearly defined objectives and a thorough understanding of individual interests form the basis of any co-operative venture. Industry-educational institution relationships are no exception. Too often one hears statements made to the effect that: They didn't tell us their real problem . . . he doesn't seem to understand that we are in business to make money . . . we have been giving them money for years without any return.

Statements such as these serve to emphasize the importance of clearly defined objectives and a thorough understanding of individual interests in any co-operative undertaking.

A growth ingredient

Technological advancement has two effects. Industrial growth and development in the years ahead are both going to be increasingly dependent upon well-staffed and equipped institutions for training technical personnel. Moreover, the growth of individual corporations depends in part upon more effective use of these institutional facilities.

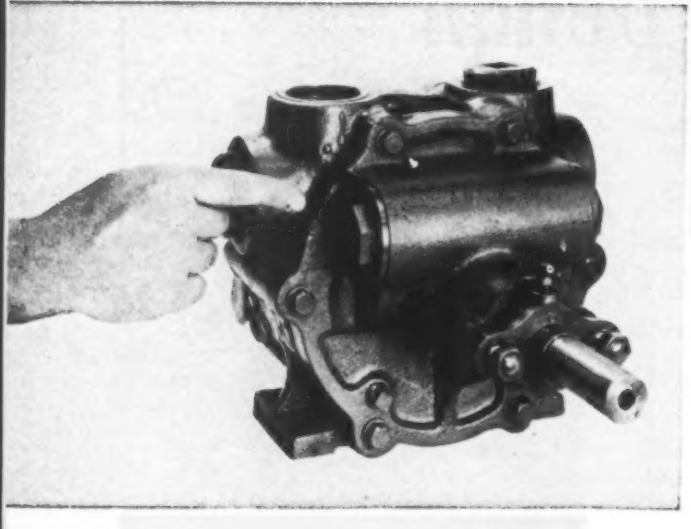
Well-developed university and college relationships are a growth ingredient essential for industrial development in the tomorrows. Companies alert to tomorrow's problems recognize the relationship between professors and profits

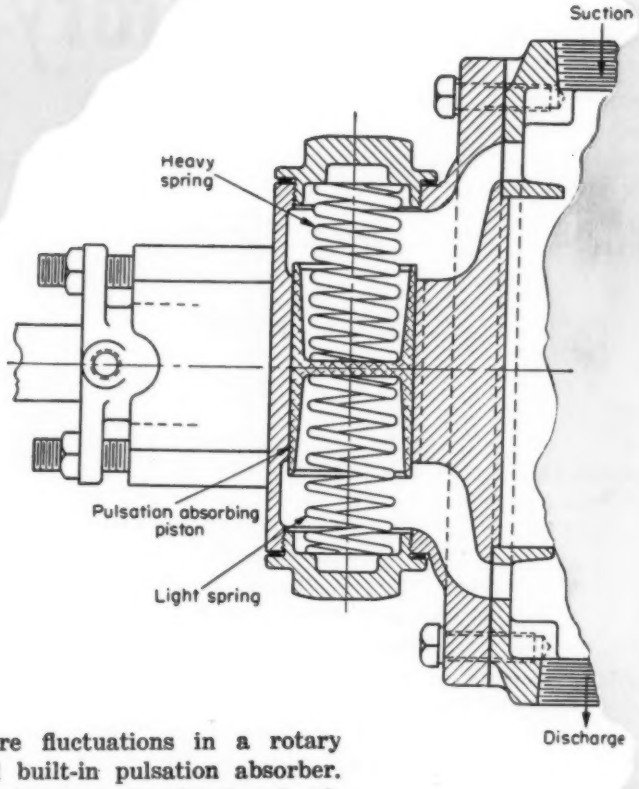
Contemporary Design

Ice Cube Maker Slices Slab

A NEW ice cube maker will automatically produce as much as 450 pounds of ice per day in the form of 1½ by 1¼-in. cubes or ⅝ by ⅝-in. cubelets. Thickness may be varied from ¼ to ¾-in. Cubelets or cubes are cut by interchangeable cutting grids from a slab of ice made by the machine. During the freezing cycle, water is circulated over a freezing plate until a slab of required thickness is formed. The slab is then automatically transferred to the cutting grid. Cut ice then drops into a storage bin. A full bin automatically stops the process. Dimensions of the unit, made by Frigidaire, are 48⅛ in. high, 29¾ in. deep and 7¾ in. high.

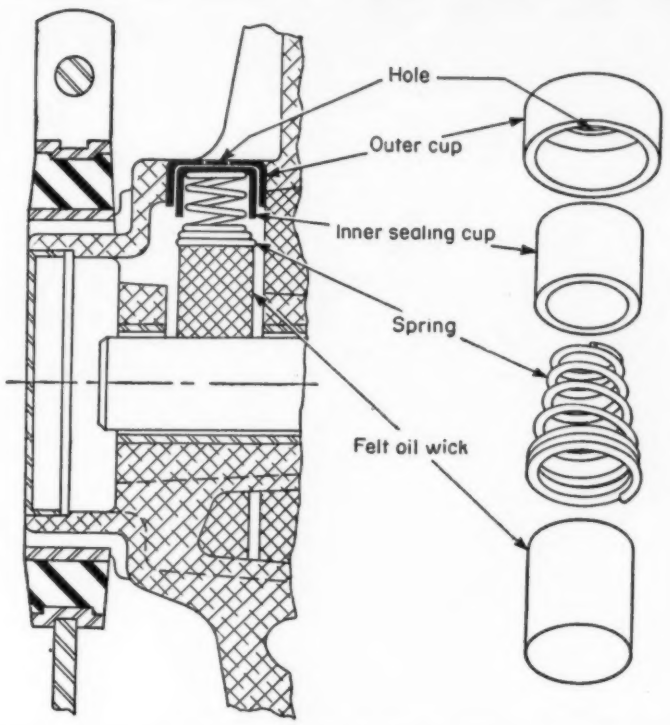
scanning the field for *Ideas*





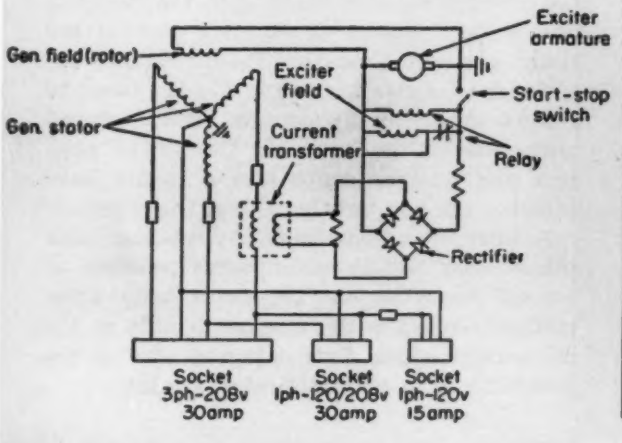
AUTOMATIC DAMPING of pressure fluctuations in a rotary pump design is achieved with a novel built-in pulsation absorber. Constructed as a part of the pump-shaft housing, the absorber developed by the Tri-Rotor Pump Dept. of the Yale & Towne Mfg. Co. consists of a cylinder connected across suction and discharge ports of the pump. Mounted in the cylinder is a lightweight piston which operates against a heavy spring on the suction side and a light spring on the discharge side. When a pressure peak is produced at the discharge port by a flow impulse, the piston moves toward the suction side. This action relieves the pressure peak and simultaneously compensates for the corresponding suction increase developed at the pump intake. Vibration and pounding in both suction and discharge lines are reduced by the design which immediately dampens recurrent or momentary shock pressures without reducing operating capacities.

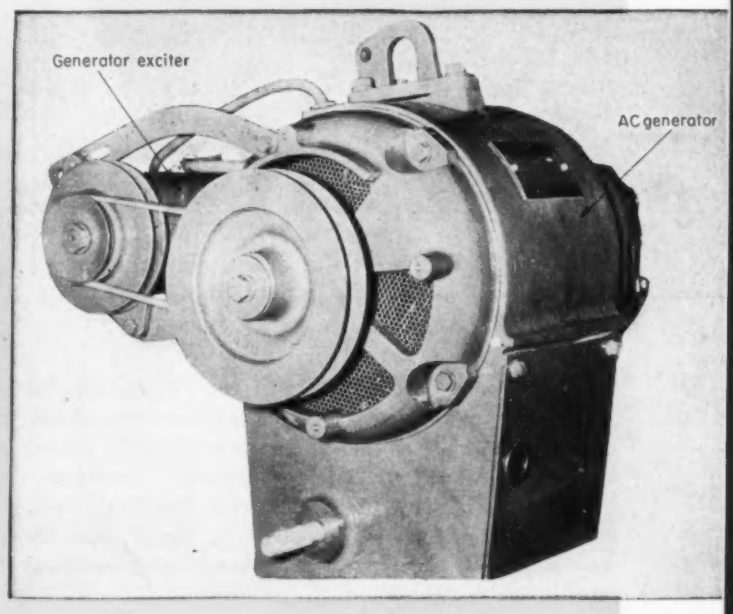
FLUSH-MOUNTED OIL FITTING developed by Emerson Electric Mfg. Co. offers a neat self-sealing construction with cost advantages. Employed on electric motor housings, the design is composed of a spring, a felt wick and two cup-shaped metal stampings which are mounted concentrically. Lubricant is admitted to the felt wick "reservoir" by depressing the spring-loaded inner cup to uncover a hole in the larger cup which is mounted flush with the surface of the housing.



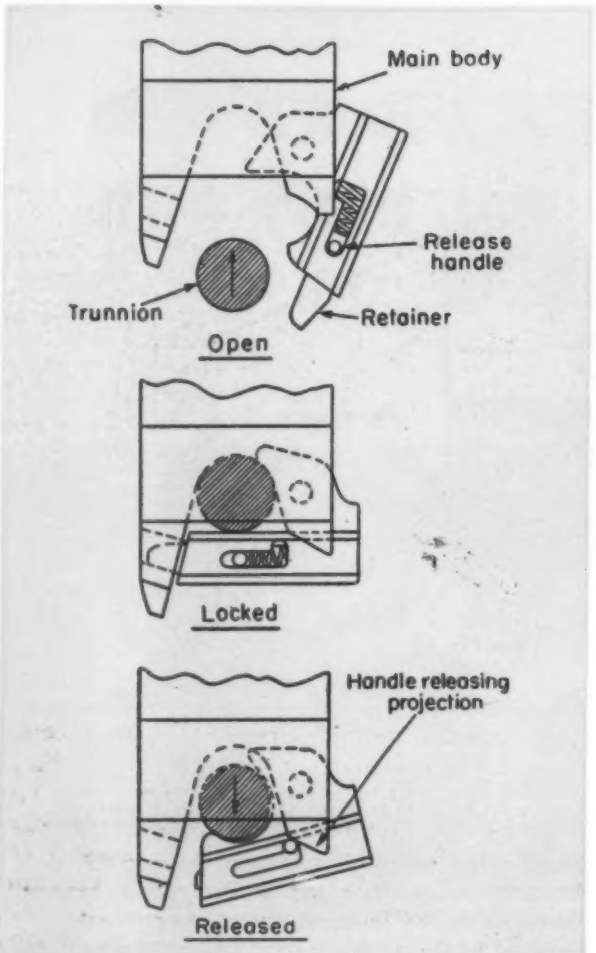
CURRENT "COMPOUNDING" CIRCUIT DESIGN for ac generators maintains accurate voltage regulation under high-peak current loads. In a system developed by General Electric Co. for application on International Harvester farm tractors, a novel compounding scheme is utilized in the voltage control circuit of three-phase generators to assure adequate electric power for starting and intermittent high-torque loads without the possibility of excessive field currents at light and normal loads.

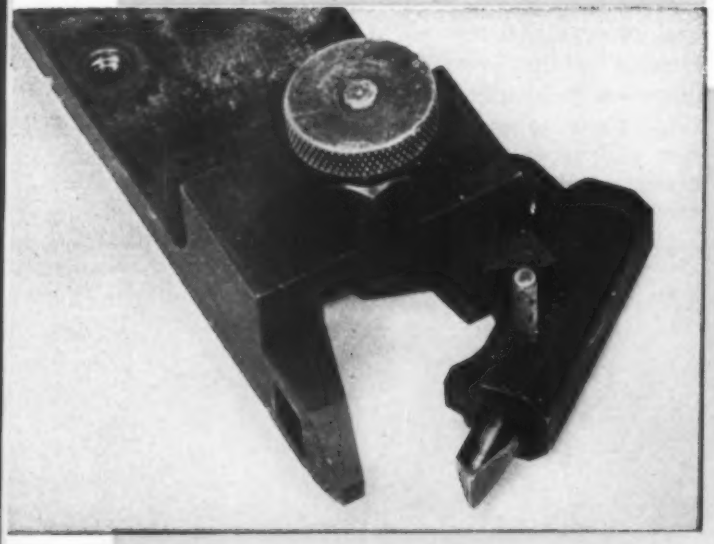
In this circuit design, dc current for the exciter field is supplied by two sources connected in series: the exciter armature and a current transformer-rectifier combination. Current output of the exciter armature is a function of main generator shaft speed while dc output of the current transformer-rectifier set is controlled by demands on the main ac circuit. As current demand in the ac generator lines increases, current through the exciter field, and thus the generator field, is automatically increased by the current transformer. This increased field strength in the generator rotor tends to counteract armature reaction and other internal generator voltage drops when current loads are heavy.





IDEAS

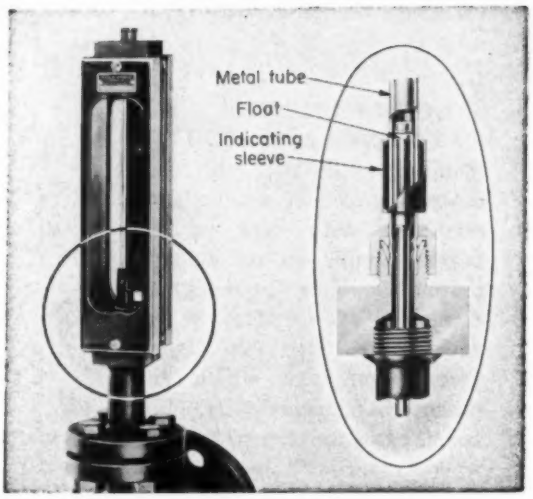




POSITIVE LOCKING for retention of heavy machine assemblies under severe shock and vibration loads is assured by a novel quick-release latch mechanism. Developed by H. G. Benis of the Aircraft Products Dept. at General Electric Co., the latch was designed to facilitate installation and removal of relatively heavy armament units and is capable of withstanding the adverse service conditions associated with the firing of modern automatic weapons.

This locking unit is composed of three parts: the main body, a pivoted dog, and a spring-loaded retainer. As a cylindrical trunnion on the mounted assembly approaches the body, engagement is made with the rear tab of the dog causing it to pivot toward the closed position. Near the closed position, the spring-loaded retainer in the dog is caused to retract gradually by contact with a sloped projection on the body. In the locked position, the retainer snaps into a square hole, pressing the dog tightly against the trunnion.

Release is accomplished by pulling back the retainer handle to its locked position. A second projection on the main body automatically releases the retainer handle as the dog swings open. This action eliminates the possibility of a malfunctioning retainer.



VISUAL FLOW INDICATION by means of a magnetic follower system simplifies design and construction of high-pressure metering circuits. Conventional glass parts are eliminated in a construction, developed by the Brooks Rotameter Co., which employs a nonmagnetic metal extension tube to transmit flow information. Riding inside the extension tube is a float which carries a permanent magnet. On the outside of the extension, a light-weight indicating sleeve moves in response to any change in float position. The magnet in the float acts to hold the sleeve in permanent bond with the float position.

Developments in design and application of

FLANGE TYPE ELECTRIC MOTORS

By C. R. Sutherland*
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Cleveland, Ohio

Several types of flange or face-mounted motors have existed as NEMA standards for a number of years.

Currently, a new approach to standardized flange-mounted motors, primarily for use with gearmotors, is being explored by the American Gear Manufacturers Association.

This discussion presents the essential features of the NEMA standard flange motors and outlines some of the thinking behind AGMA's work in establishing proportions for a standardized motor for gearmotor service. But, as developed for this service, these new flange motors may possess features which suit them for other services as well.

To build into the proposed standard features of widest possible utility, the AGMA task group conducting this work will welcome suggestions and comments.

1. **Will improved interchangeability of motors and reducers be particularly advantageous to gearmotor users?**
2. **In what other specific design areas will the new approach provide significant help?**
3. **What other factors might be readily incorporated in the standard?**

Discussion of these points and any others may be addressed either to the author, or to Editor, *Machine Design*, Penton Bldg., Cleveland 13, O.

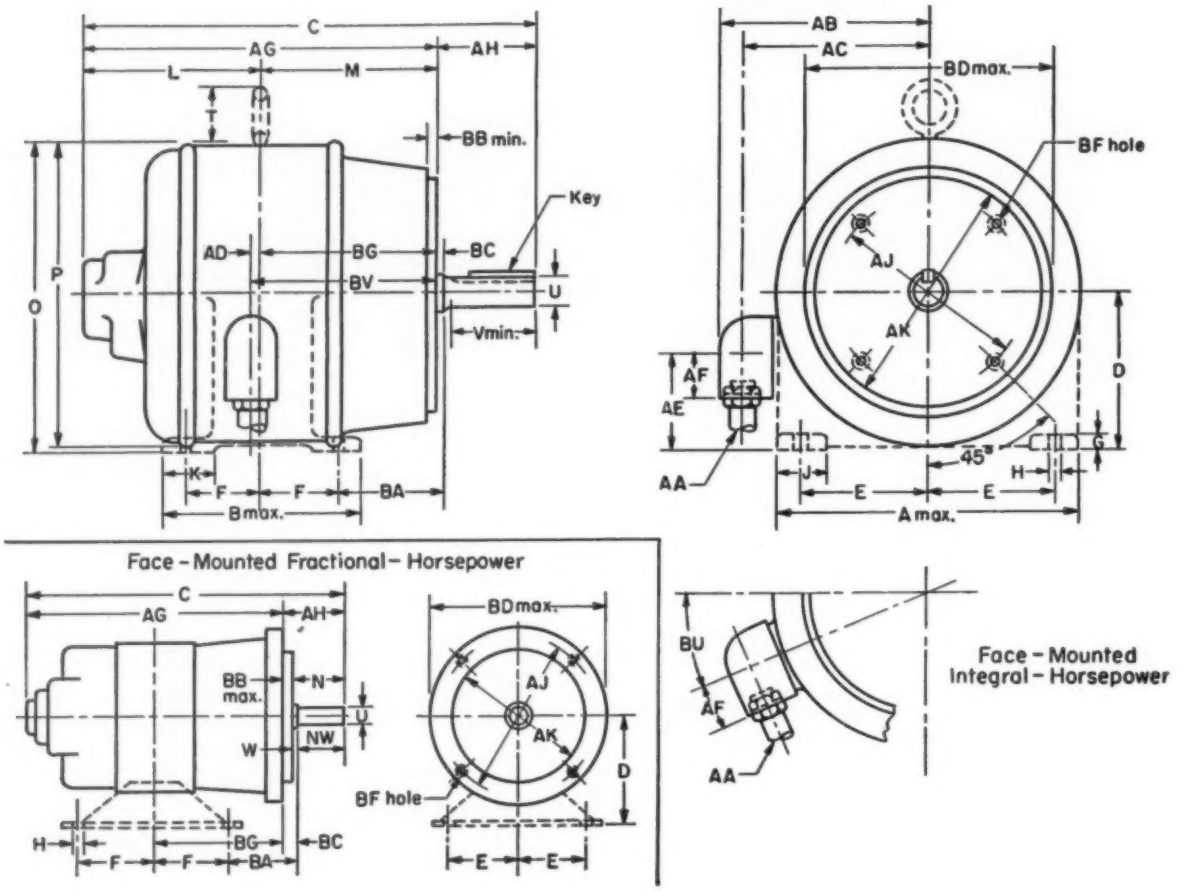
ELECTRIC motors are more and more becoming integral parts of the machines they drive. When electric motors were first introduced into industry, they were frequently mounted on the ceiling and drove a number of machines with a forest of belts. Today, through product integration, they are skillfully mounted on machines to create a harmonious piece of apparatus that does the job efficiently and is easily serviced.

Efforts to Standardize: Foot-type electric motors bolted to a base and coupled, or driving through belts or gears, is the conventional manner of applying an electric motor to a pump, compressor, or machine tool. It is an excellent and satisfactory method of motor and apparatus arrangement and should be popular for many years to come. However, when space is a limiting factor, or further economies are necessary, a motor flange mounting may prove desirable. Flange mountings are not new; they were formerly specified through sheer necessity and as such were considered special. Today, through standardization efforts, a number of different kinds of flanges are available. One of the national standardization groups, National Electrical Manufacturers Association, has designated these more popular flanges as NEMA Types C, D and P. The first two, NEMA Type C face-mounted and NEMA Type D flange-mounted, have universal application. Constant demand and usage have created these standards. Their dimensions are tabulated on *Figs.* 1 and 2.

NEMA Flange Motors: A NEMA Type D flange-

*Member of gearmotor and co-chairman of gearmotor motor task committee, American Gear Manufacturers Association; chairman of subcommittee on standards for mounting gearmotors and pinions, National Electrical Manufacturers Association.

Fig. 1—Standard dimensions for Type C face-mounted motors. From NEMA Pub. No. MG1-1955



Frame Number	U	AH	AJ	AK	BB Min	BO	BD Max	BF Hole Number	BF Hole Tap Size	BF Hole Min Depth
182C	⅞	2⅛	5⅞	4½	$\frac{5}{32}$*	−⅛	6½†	4	⅜–16	$\frac{3}{16}$
184C	⅞	2⅛	5⅞	4½	$\frac{5}{32}$*	−⅛	6½†	4	⅜–16	$\frac{3}{16}$
213C	1⅛	2¾	7¼	8½	¼	−¼	9	4	½–13	¾
215C	1⅛	2¾	7¼	8½	¼	−¼	9	4	½–13	¾
254UC	1⅜	3½	7¼	8½	¼	−¼	10	4	½–13	¾
256UC	1⅜	3½	7¼	8½	¼	−¼	10	4	½–13	¾
284UC	1⅜	4⅝	9	10½	¼	−¼	11¼	4	½–13	¾
286NC	1⅜	4⅝	9	10½	¼	−¼	11¼	4	½–13	¾
324UC	1⅜	5⅝	11	12½	¼	−¼	14	4	⅝–11	$\frac{11}{16}$
324SC	1⅜	3	11	12½	¼	−¼	14	4	⅝–11	$\frac{11}{16}$
326UC	1⅜	5⅝	11	12½	¼	−¼	14	4	⅝–11	$\frac{11}{16}$
326SC	1⅜	3	11	12½	¼	−¼	14	4	⅝–11	$\frac{11}{16}$

*Maximum for frame numbers 182C and 184C only.

†Nominal for frame numbers 182C and 184C only.

Tolerances:

AK dimension
182C to 286UC frames, incl.: +0.000, −0.003 inch.
324UC to 326SC frames, incl.: +0.000, −0.005 inch.

Face runout
182C to 286UC frames, incl.: 0.004-inch indicator reading.
324UC to 326SC frames, incl.: 0.007-inch indicator reading.

Permissible eccentricity of mounting rabbet
182C to 286UC frames, incl.: 0.004-inch indicator reading.
324UC to 326SC frames, incl.: 0.007-inch indicator reading.

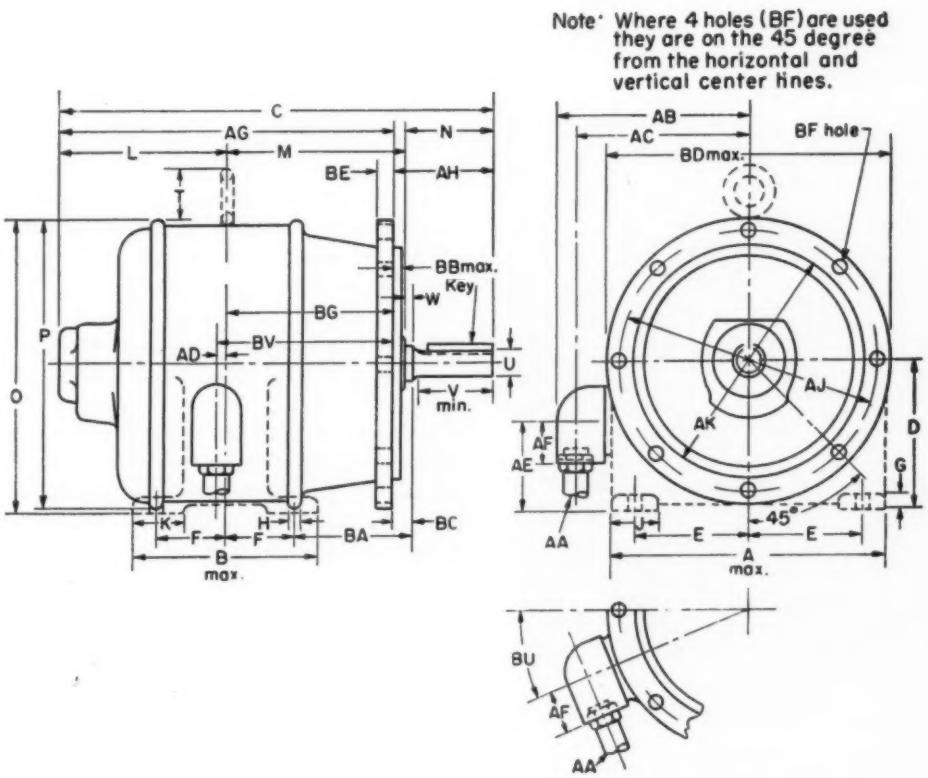
Permissible shaft runout
182C to 286UC frames, incl.: 0.002-inch indicator reading.
324UC to 326SC frames, incl.: 0.003-inch indicator reading.

type motor is furnished either with or without feet. It is frequently bolted to a machine body and used to transmit energy through a gear train. Such mountings, used to drive a gear train, chain, or sometimes a coupling, are not uncommon. An oil-tight case is highly desirable when lubrication must be provided for the chain or gear. In addition to these factors, a simple and accurate method of mounting the motor is attained. The principal objection to such a flange mounting is that radial adjustment for chain or belt tightness is not directly available and requires the use of a rather special adjustable type flange adapter.

While NEMA Type D flanges are considered primarily as a support for the motor, their use has extended in another direction. Foot-type flange motors have been used to support a pump, gear box or some other accessory. It is understandable that the weight of such accessories is limited by the strength of the motor feet which must support both the accessory and the motor. *Fig.* 3 shows a foot-type NEMA flange motor supporting a single-stage gear unit.

The other popular flange motor is a NEMA Type C face-mounted, *Fig.* 4. It was developed and stand-

Fig. 2—Standard dimensions for Type D flange-mounted motors. From NEMA Pub. No. MG1-1955



Frame Number	AJ	AK	BD Max	AH	BC	BB Max	BE Nominal	U	Key Width	Key Thickness	Clearance Hole BF Size	Clearance Hole BF Number	Rec. Bolt Length
182D and 184D	10	9	11	2¼	0	¼	½	⅞	3/16	3/16	11/32	4	1¼
213D and 215D	10	9	11	3	0	¼	½	1⅛	¼	¼	11/32	4	1¼
254UD and 256UD	12½	11	14	3¾	0	¼	¾	1⅜	5/16	5/16	13/32	4	2
284UD and 286UD	12½	11	14	4⅜	0	¼	¾	1⅜	⅜	⅜	13/32	4	2
324UD and 326UD	16	14	18	5⅝	0	¼	¾	1⅞	½	½	13/32	4	2
324SD and 326SD	16	14	18	3¼	0	¼	¾	1⅝	⅜	⅜	13/32	4	2

All dimensions in inches.

Tolerances:

AK dimension
182D-2S6UD frames, incl.: +0.000, —0.003 inch.
324UD-326SD frames, incl.: +0.000, —0.005 inch.

Face runout
182-286UD frames, incl.: 0.004-inch indicator reading.
324UD-326SD frames, incl.: 0.007-inch indicator reading.

Permissible eccentricity of mounting rabbet
182D-2S6UD frames, incl.: 0.004-inch indicator reading.
324UD-326SD frames, incl.: 0.007-inch indicator reading.

Permissible shaft runout
182D-2S6UD frames, incl.: 0.002-inch indicator reading.
324UD-326SD frames, incl.: 0.003-inch indicator reading.

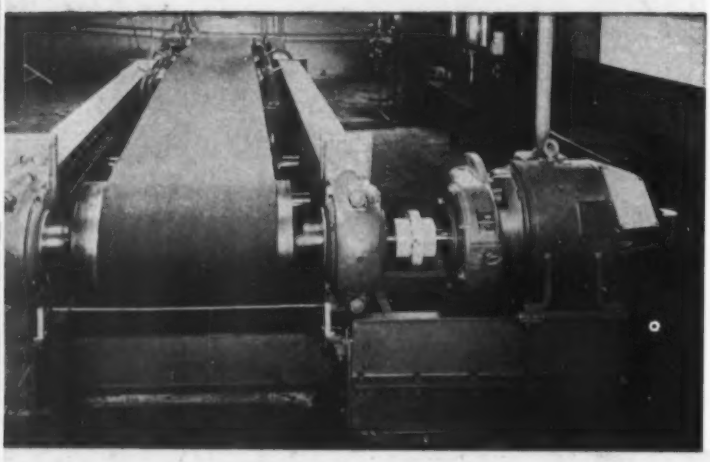
ardized by virtue of its acceptance within the pump and hydraulic industries. It can also be used on vertical drives. It should be noted that the tapped mounting holes are beyond the rabbet mounting diameter, and the flat face of the end bell is used for axial register.

Where a footless NEMA C motor is desirable, it must be secured to the housing by passing the bolts of the motor through the supporting member, and into the motor. It is obvious from the dimensions of this motor that the housing must be of adequate proportions to provide wrench clearance for fastening the motor. In the main, however, the NEMA Type C foot and footless-type flange motors are utilized in pump and other small accessory applications.

Another standardized flange is the NEMA Type P. Motors with NEMA Type P flanges are designed with a flat extended lip at right angles to the center-line of the shaft. This type of extended flange is easy to apply. The motor can be centrally located by means of an axially extended lip located near the flat of the flange. Clearance holes for the bolts are drilled through the flat. Bolts are inserted from the motor side, passed through the flange, and secured into the machine supporting the motor. At times it is desirable to use studs for holding the motor; lock washers and nuts are then secured from the motor side. NEMA Type P flange is widely used in conjunction with deep-well pumps, but is not often employed in equipment such as machine tools. It is usually constructed as a footless type of motor and comes with a rabbeted flange similar to the NEMA Type D, except for a difference in the flange proportions and register.

Many special flange designs have been made to meet various requirements, *Fig.* 5. However, development and design of special flange motors are expensive. Since many applications require motors with different voltages, frequencies, horsepowers, and speeds, the cost of creating a full line of special but interchangeable flanges becomes somewhat prohibitive. On the other hand, there are many applications where the cost of a special-purpose flange will offset the added development cost for patterns and tools.

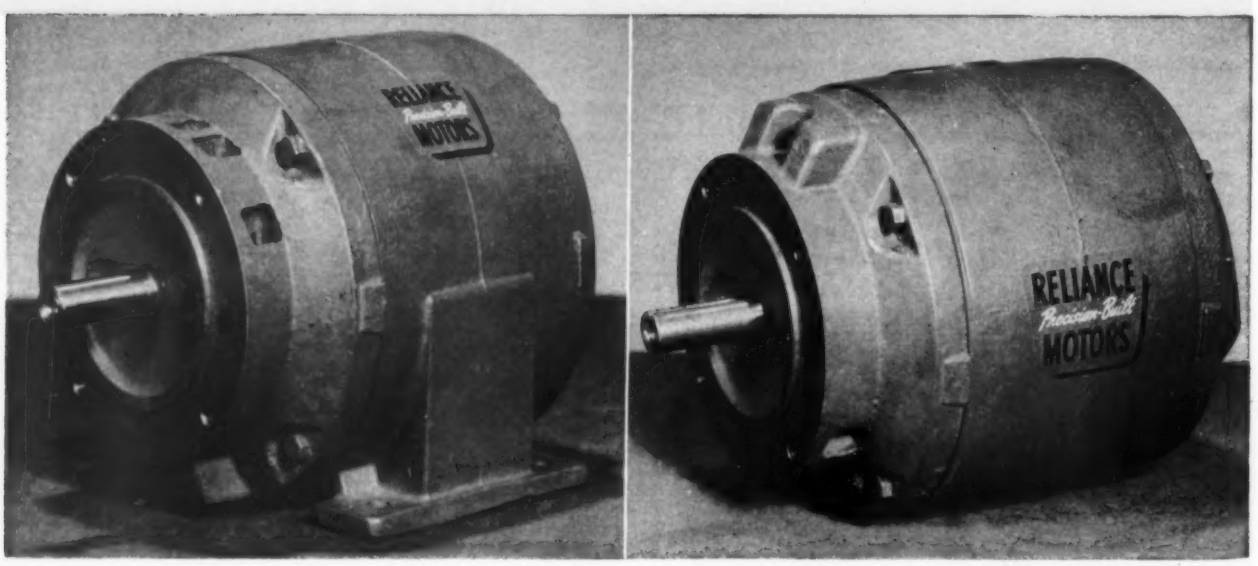
Fig. 3—Foot-type motor, with NEMA Type D flange, used on a single-stage gearmotor



Gearmotor Flange: It is interesting to note the great importance attached to flange motors, particularly as it affects an entire industry. In 1952 the American Gear Manufacturers Association created a gearmotor motor task committee. The directive to the task group was to review the gearmotor mounting problems and determine the most suitable and universally accepted motor mounting for the greatest number of gearmotor manufacturers.

Many aspects of the design problem were studied Recommendations had to take into account the needs and problems of users, electric motor manufacturers, and the gearmotor producers. It is not AGMA's responsibility to create a standard gear-

Fig. 4—Typical NEMA Type C foot and footless-type motors



motor motor, but it does wish to recommend a desirable gearmotor motor mounting which can utilize the best features in a flange-type motor. The path taken has been to attempt first to consider how the gearmotor mounting design would affect the electric motor, and then determine the requirements of a suitable motor.

The objective of this program is to provide for the mounting of any standardized flange gearmotor motor on any standardized gearmotor reducer. Such a standardized motor, if available, could then be interchanged or mounted on any other gearmotor. *Fig.* 6 shows three different designs used at present to mount electric motors to gearmotors. The variations in mounting can be discerned quite easily.

Standard Gearmotor Motor: Certain objectives have been set up in the program for establishing common dimensions for a gearmotor motor:

1. Standard flange dimensions
   a. Flange rabbet diameter
   b. Flange face width
   c. Bolt circle diameter
   d. Bolt size, number of bolts, and angular position of bolts
2. Bearings
   a. Location
   b. Lubrication method and sealing
3. Shaft
   a. Location
   b. Method of pinion mounting

Status of the program at this time is shown by the partial proposal in *Fig.* 7.

Flange proportions have to be such that they will be entirely compatible with the wide-range usage of electric motors on gearmotors. This is a very critical area because the rating of a motor and its eventual combination with two or more gear frames dictates what the best proportions for the flanges should be. Basically, a flange similar to the NEMA Type D flange was found most suitable for general construction.

A number of basic factors had to be juggled in developing a final proposal.

Flange OD had to be as near the basic diameter of the motor body as possible, and at the same time, the flange OD had to be at least ½-inch smaller than the rabbet fit of the next larger motor flange. This was a design necessity to permit the mounting of smaller frame size motors, with adapters, on motor and gear box combinations which were so built wherever service factors dictated. A considerably smaller flange OD would have been highly desirable, but it did not permit removal of mounting bolts without increasing the length of the motor excessively. The question of using adapter rings was quite important and played an important part in establishing the flange dimensions, particularly as applied to the use of this line of motors on gearmotors.

Flange face width was important since it related

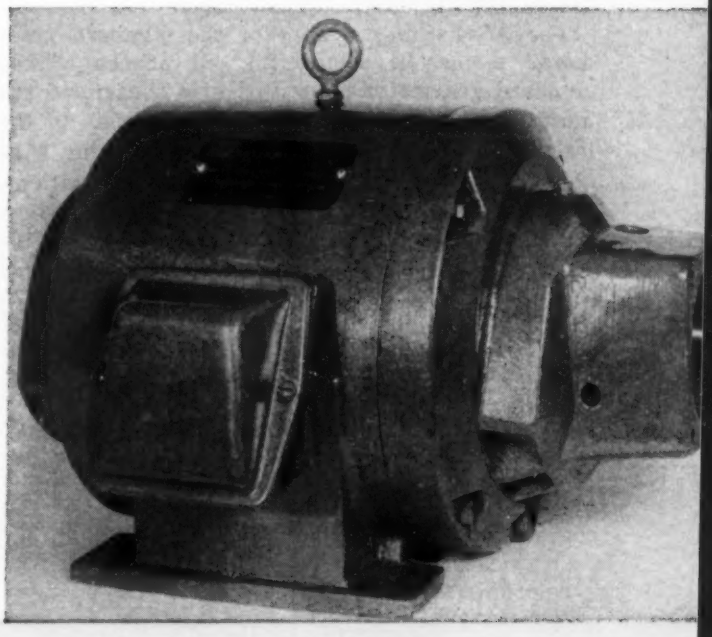
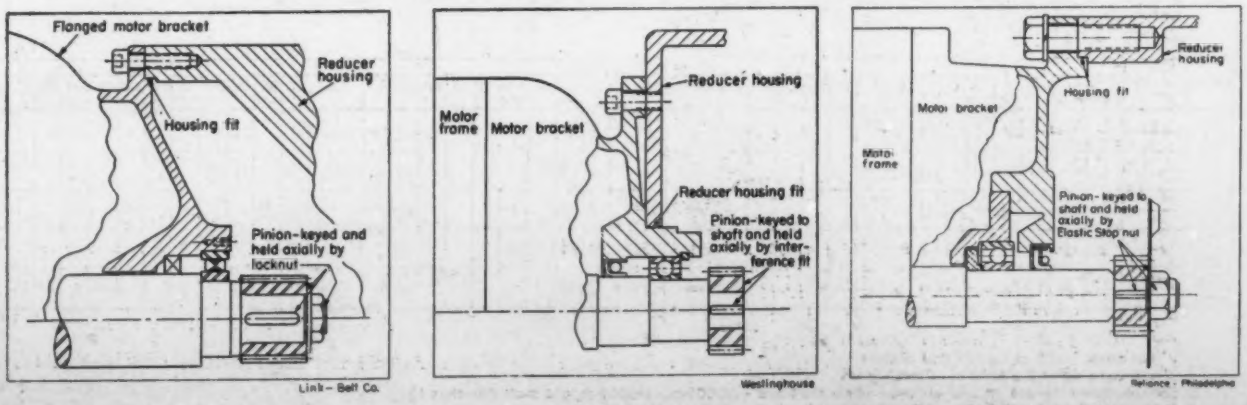


Fig. 5—Above—Special flange-type motor

Fig. 6—Below—Three of the many different methods of mounting motors to reducers



to strength, adequate sealing surface, and bolt size. Actually, agreement on final face width was a series of compromises on the number of bolts, which in turn dictated size of bolts and minimum flange flat requirements.

Number of bolts, size of bolts, and spacing of bolts were important from the standpoint of rotation of the motor when the gearmotor would be wall or ceiling mounted. Accessibility to the bolts dictated the angular locations.

Locations of the flange and bearing were also studied. Obviously the bearing should be located as close to the load as possible. For a gear reducer, the centerline of the load or pinion could not be moved toward the motor, or could not easily be moved toward the bearing because the mating gear would interfere with the flange mounting. Therefore, the logical pinion location was well within the gear housing. This meant that the bearing should project beyond the flange and into the gear housing as shown in *Fig.* 7. This arrangement of bearing location would be also highly desirable when such a flange motor might be used to drive a chain or gear without interference from the supporting case.

The AGMA task group for the standard gearmotor motor, in considering all phases of the standard gearmotor mounting, also considered the most suitable shaft extension for pinions. In the interest of creating a single motor mounting suitable for a wide range of gearmotor applications, the group must establish a standard pinion shaft mounting. Several proposals are now under consideration. A hollow shaft is one possibility. This type of pinion mounting would permit inserting a wide variety of pinion size diameters and face widths, a highly desirable factor for mounting pinions with extremely small diameters.

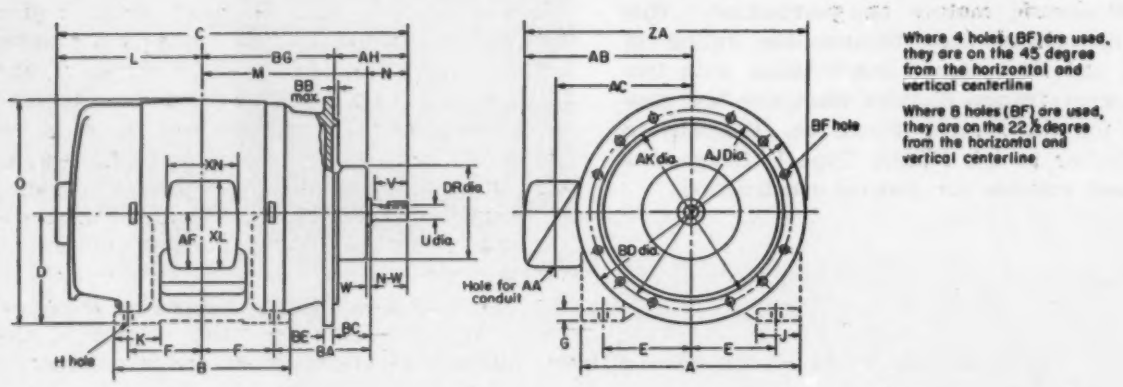
Summary: Growing use of flange-type motors is justified by several benefits. Flange-mounted motors can be installed closer to the driven machines, a factor in product integration. An oil-tight housing can be provided where necessary. Overall length of the application can be reduced. The motor can be made to blend into the machine.

Foot-type flange motors are proving economical when accessories can be close-coupled and supported from the motor. This type of construction eliminates the cost of a base.

The interest shown by the gear industry, as indicated by the action taken by AGMA, is further evidence of the potential value of standardized motor flanges for gearmotors. Development of a proposed standard on flange motors for gearmotors is well along the road, but several questions must be resolved.

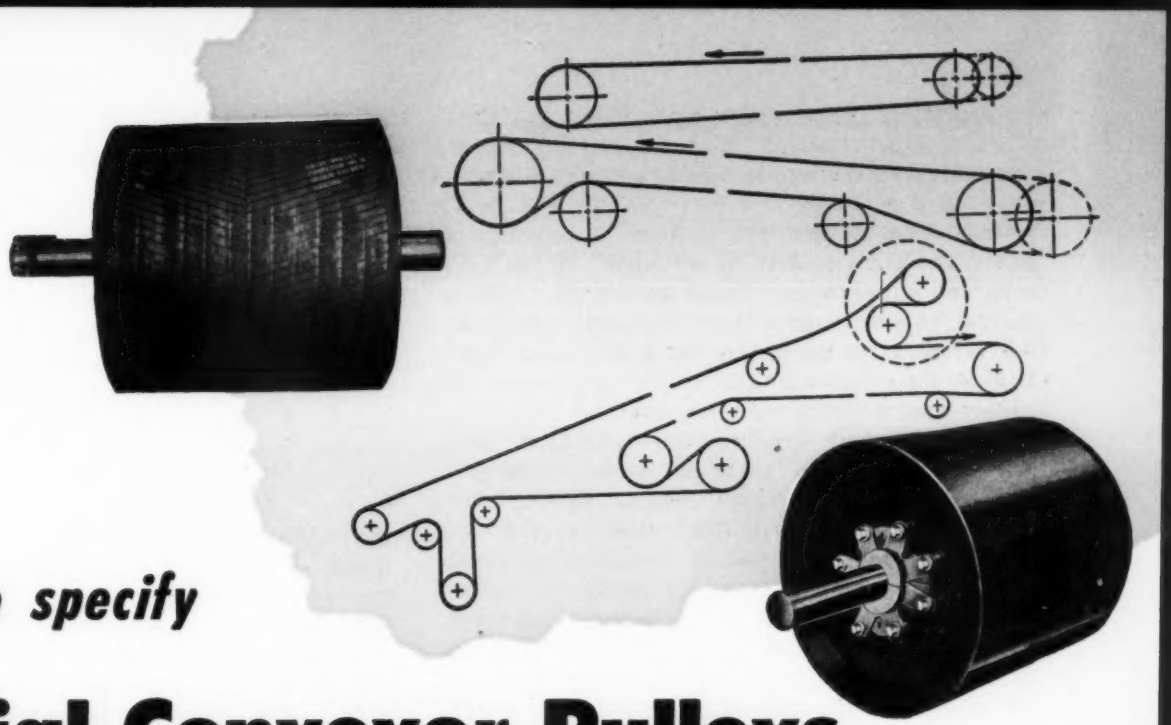
Motor and gearmotor users may well be able to aid this work by offering suggestions or criticisms to the AGMA task group. Write to the author, or to Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Fig. 7—Motor dimensions proposed by AGMA for gearmotors



Frame		Dimensions (inches)																																						
		Key Width	Key Thick	Key lgth	A max	B max	C	D ◊	E	F	G	H	J	K	L	M	N	N-W	O	U □	V+ min.	W	AA min.	AB	AC	AF	AH	AJ	AK	BA	BB max	BC	BD max	BE nom.	BF	No. holes	BG	DR max	XN	XL	ZA
182		3/16	3/16	1 1/8	9	6 1/2		4 1/2	3 1/4	2 1/4		13/32						2 1/4		7/8	2		3/4				3 1/2	8	7.250 / 7.248	4		1 1/4	8 3/4	7/16	13/32	4		2 7/8			
184						7 1/2				2 3/4																															
213		1/4	1/4	2	10 1/2	9		5 1/4	4 1/4	3 1/2								3		1 1/8	2 3/4						4 1/2	10	9.250 / 9.248	5		1 1/2	10 3/4					3 1/2			
215																																								
254		5/16	5/16	2 3/4	12 1/2	10 1/2		6 1/4	5	4 1/2 / 5		17/32						3 3/4		1 3/8	3 1/2		1				5 1/2	12 1/2	11.250 / 11.248	6 1/16	3/16	1 3/4	13 1/4	1/2		8		4 1/4			
256						12 1/2																																			
284		3/8	3/8	3 1/4	14	14		7	5 1/2	4 3/4 / 5 1/2								4 7/8		1 3/8	4 3/8		1 1/4				6 3/4			6 3/16				3/4	17/32			5 1/4			
286																																								
324		1/2	1/2	4 1/4	16	16		8	6 1/4	5 1/4 / 6		21/32						5 3/8		1 7/8	5 3/8		1 1/2				7 7/8	15	14.002 / 13.998	7 3/16		2 1/4	16	5/8				6 1/4			
326																																								

+ "V" represents length of straight part of shaft.
◊ "D" will come within the limits of +0 inch, −1/32 inch
□ Shaft diameters 1 1/2 and smaller will come within the limits +.0000 inch, −.0005 inch, and shaft diameters 1 5/8 and larger will come within limits +.000 inch, −.001 inch.



When to specify

Special Conveyor Pulleys

By Randolph H. Jackson
American Pulley Co.
Philadelphia, Pa.

DESIGNERS of conveyor systems working with normal loads sometimes specify diameter, face and bore of the conveyor pulley—and let it go at that. But, as loads increase, conveyors lengthen, and pulleys grow larger, maintenance men begin to have their share of broken-out pulley rims, cracked spokes, and pulleys which have "walked" on their shafts even when furnished with clamped hubs.

Why? Well, for one thing, the development of synthetic and steel-cable cord belts has greatly increased the ability of the belt to carry higher stresses. As a result, heavier tonnages are being moved on belt conveyors for longer distances, and pulleys have become a critical factor in design.

Standard pulleys are satisfactory for most installations. But under increased loads, special attention must be given to pulley selection, and particularly the relation between pulley design and design of the supporting shafts and bearings. These factors will be considered.

Life of any conveyor belt is particularly dependent upon the proper selection of pulleys. Capacity of a pulley is rated in terms of the "resultant belt loads," the force exerted as the result of belt tensions at the pulley. The resultant belt load is a function of the arc of contact between the belt and pulley. On idling pulley (nondriving head, tail, take-up, bend, snub, or tripper pulleys), the resultant belt load may be twice the tension of the belt at the specified pulley, *Fig.* 1.

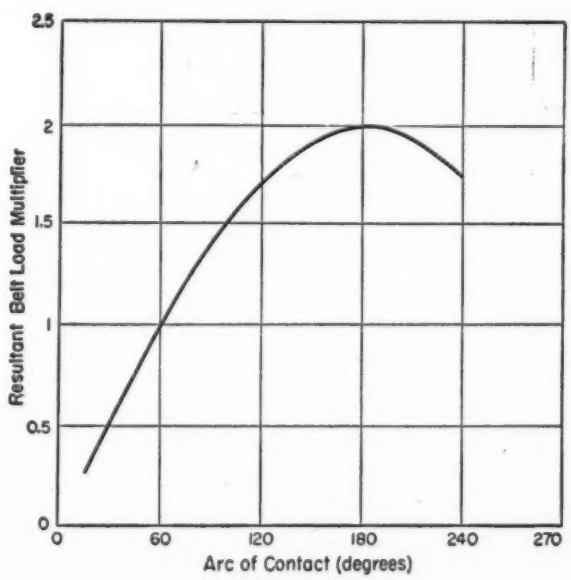


Fig. 1—Belt tension is multiplied by a factor depending upon arc of belt contact to determine the "resultant" belt load on a pulley

Ability of a particular pulley to withstand the resultant belt load depends upon type of pulley, size and shaft size. Additional factors are:

1. Distance between centers of its shaft bearings (The greater the center distance, the smaller the pulley capacity.)
2. Shaft diameter. (The larger the shaft, the greater the pulley capacity for a given hub size.)

3. Allowable shaft stress used in selecting the shaft.
4. Arc of contact of the belt around the pulley.

Hubs and Disks: The problem in selecting a pulley for exceptionally heavy service is to have sufficient strength and flexibility in the disks to prevent breakage due to combined radial and bending stresses in the disks, hubs and hub bolts. Proper design of the hub and pulley keeps the pulley from walking on the shaft.

In a welded steel pulley, the disks must be a prime consideration. It is advantageous to permit the hubs to gyrate with the shaft as it deflects. However, stresses in the disks must be held to a point low enough to permit indefinite operation without fatigue and resulting breakage due to this gyration. A steel pulley with a thin disk, *Fig.* 2*a*, allows the shaft to deflect because the disk is not thick enough to restrain the shaft. A pulley with really thick disks, that will not bend appreciably as a result of the bending moments applied to them through the shaft, causes all shaft deflection to be carried from the hubs outward as shown in *Fig.* 2*b*. Between these two extremes of disk thickness is an area, *Fig.* 3, involving high stresses in the disks, very high bending moments on the hubs, and likely pulley failure.

The disadvantage of employing thick disks to reduce stress is that the bending moment on the hub, and therefore on the hub bolts, is increased. Also there is a tendency for a hub bore to wear and "bell-mouth," thus permitting the pulley to walk on the shaft.

When the hubs or end disks are close together, the angular deflection of the shaft at the point of hub location is small; thus disk flexing stress is reduced. If disks are far apart, shaft deflection is also reduced and thus disk stress is less. Somewhere between those two extremes the shaft deflection for a given loading must reach a maximum. This occurs when the center-to-center distance between disks is approximately equal to half the center-to-center distance between bearings. In most pulley applications the logical location of the hubs is nearly flush with the edges of the rims. Some clearance is advantageous because pillow blocks usually nestle very close to the edges of the pulley rim.

A second major point to consider is the hubs. *Fig.* 4 shows a standard welded-steel conveyor pulley. This type of pulley uses interchangeable bolted tapered hubs that mate with tapered bores in the disks. Hubs are held tightly in position by six or eight bolts, depending upon the hub size. Reasons for the tapered fit are:

1. To provide a positive engagement between the hub and the disk to withstand the direct belt-pull load which must be transmitted from the rim of the pulley through the disk and hub to the shaft.
2. To clamp the hub firmly to the shaft.

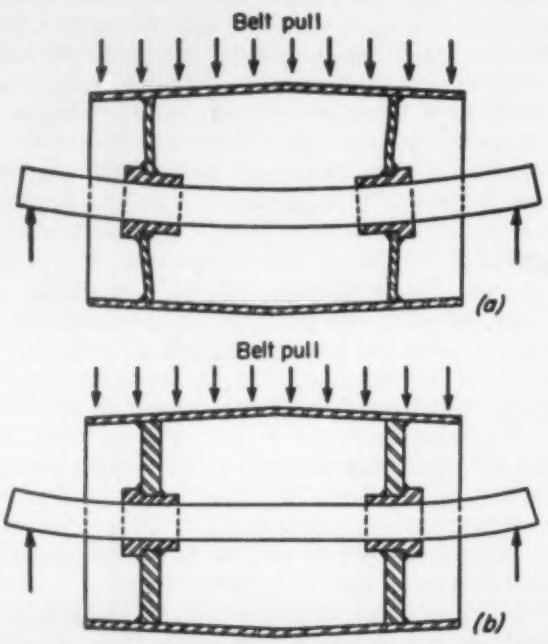


Fig. 2—Thin disks, *a*, permit the shaft to deflect along its full length, while thick disks, *b*, constrain the shaft, permitting deflection only at the ends

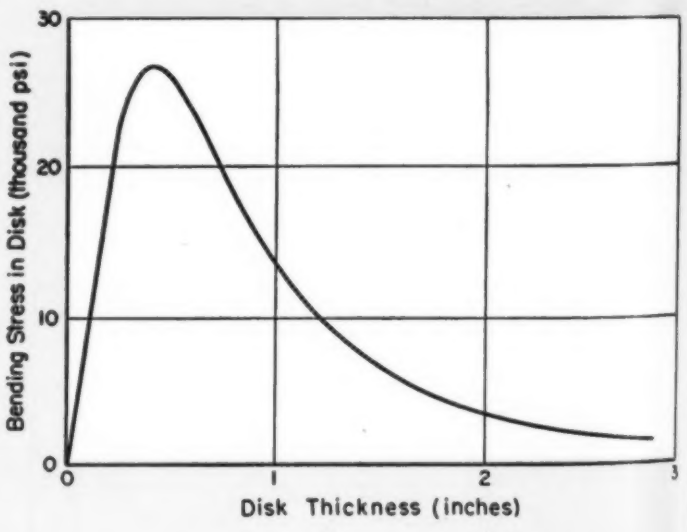


Fig. 3 — Disk bending stresses, shown for a typical small-diameter, wide-face pulley, are least when the material is either very thin or quite thick. Compressive stresses, of course, must also be considered

When each hub is drawn into place, its tapered shoulder locks into a tapered center hole in the disk, thus taking the belt pull and much of the driving load off the bolts and reducing wear of hubs, disks, and bolts. Furthermore, when these bolts are tightened, the split design causes the hub to be tightly clamped from end to end to the pulley shaft, keeping the pulley from walking on its shaft.

Pulley Rims: Another element of the pulley that must be given a great deal of attention is the rim. Naturally, thicker rims must be employed for heavy-duty pulleys than for light-duty pulleys, and it is natural to reason that there must be some relationship between the required thickness for a given belt pull, diameter of the pulley, and face width. These relationships are difficult to pin down, and it has only been as a result of a series of tests and experimental stress determinations that a rational method of determining required rim thicknesses has been obtained.

Small-diameter, wide-face pulleys with a small diameter-to-width ratio actually approach the conditions of an infinitely long cylinder. In such cases it is helpful to use a center disk, but this is only of value if it is properly installed. Deflections that occur in a pulley rim are very small and localized, and unless the center disk is a perfect fit, rim stresses may develop.

Deflection occurs in a pulley rim during operation. Although change in diameter under load is small, the rim actually distorts and can develop high stresses as a given pulley section rolls from a point of no-load into a point under the belt where it is heavily loaded. The distortion occurs at the transition point between no-load and full-load on the pulley. Thus, any one section of the rim is subjected to two full reversals every revolution. Obviously if the rim is welded, as most of them are, it is the welded joint that is subject to the most suspicion. Full weld penetration is necessary so that the joint does not have an inherent notch effect, resulting in a stress-raiser capable of causing premature failure.

Pulley-Belt Relationship: For a straight-running conveyor system, pulley-belt relationship is extremely important. When a belt does not run straight it may be damaged by rubbing against structures and will not receive material evenly, but is inclined to gather an excessive load along one side. This leads to wasteful spillage. Spillage onto the return side of the belt may also cause damage to it.

A symmetrical pulley, properly crowned and correctly installed will help keep a belt running straight and true. On very heavy-duty conveyors operating at ultrahigh tension, however, the tendency is to specify straight-face pulleys at the points of maximum belt tension.

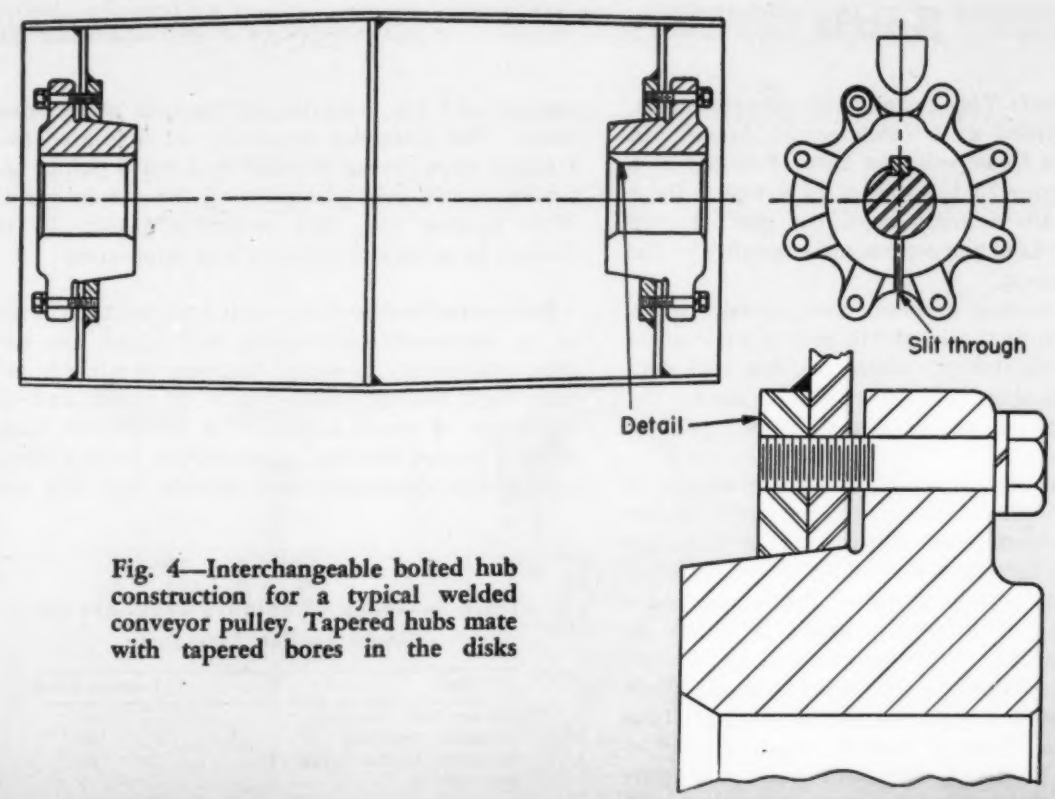


Fig. 4—Interchangeable bolted hub construction for a typical welded conveyor pulley. Tapered hubs mate with tapered bores in the disks

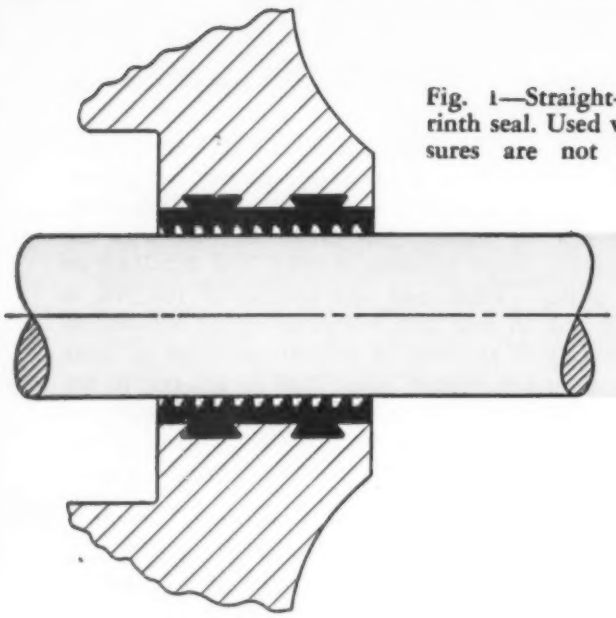


Fig. 1—Straight-pass labyrinth seal. Used where pressures are not too great

Sealing High-

By Donald F. Crego, *Engineering Supervisor*
DeLaval Steam Turbine Co., Trenton, N. J.

A DESIGNER'S approach to a specific sealing problem is governed by his knowledge of and experiences with seals and sealing systems. Equally important is the information provided on sealing requirements and operating conditions. If an engineer or designer had been asked only a few years ago how a compressed gas at 1000 psi might be prevented from escaping between the shaft and the compressor casing, he would have advised welding. Today, centrifugal compressors with modern sealing systems can handle even higher pressures. The shaft seal is a critical component of the centrifugal compressor.

This article reviews the characteristics of shaft-sealing elements and systems developed for high-pressure gases. Although specifically concerned with centrifugal compressor applications, the discussion and the designs illustrated have much broader implications and should prove valuable in helping solve other sealing problems. Divided into two sections, the article first deals with several basic high-pressure seals or sealing elements. Then from the standpoint of design and application, a number of gas sealing systems, which employ one or more of these fundamental seals, are covered in detail.

Seals

Labyrinth Seal: The straight-pass labyrinth seal, *Fig.* 1, is regarded as a fundamental device. In essence, it acts to impede the flow of a gas in a manner analagous to the orifice in a pipe. By a dissipation of the velocity head, the gas pressure is diminished. Leakage corresponds roughly to the laws of orifice flow.

In any gas sealing problem, some consideration should be given to the labyrinth seal in view of its low cost and reliability. However, this seal does permit considerable leakage. *Table* 1 shows the relative leakage allowances for different types of seals.

Refinements of the basic design are shown in *Figs.* 2 and 3. The straight pass labyrinth is useful for a low-cost, low-pressure air or flue gas compressor. The staggered labyrinth is specified for applications involving higher pressures, and a segmental type of labyrinth would be more efficient in handling high-temperature air or exhaust gas since it maintains almost constant clearances throughout a wide temperature range, thus minimizing the effect of thermal expansion.

Clearances of fixed labyrinth seals are governed by manufacturing tolerances and are also affected by journal bearing clearances, thermal expansion and the vibration of the unit under operation. The clearance is usually so regulated that a slight interference between the knife points and the shaft will take place during the run-in period. With further use, this clearance inevitably increases to at least 0.015-inch and often more.

Segmental Carbon-Ring Seal: Another type of seal is the segmental carbon-ring seal which has been used extensively in steam turbines because it permits tight sealing, conservation of space, and the reduction of shaft length. Its design has taken several forms, varying in complexity from a simple rectangular cross-sectioned carbon ring and gar-

Table 1—Index of Relative Leakages for Single Sealing Elements

Seal	Leakage Index
Straight-Pass Labyrinth	100
Staggered Labyrinth	56
Segmental Carbon Rings	20
Dry Contact	2

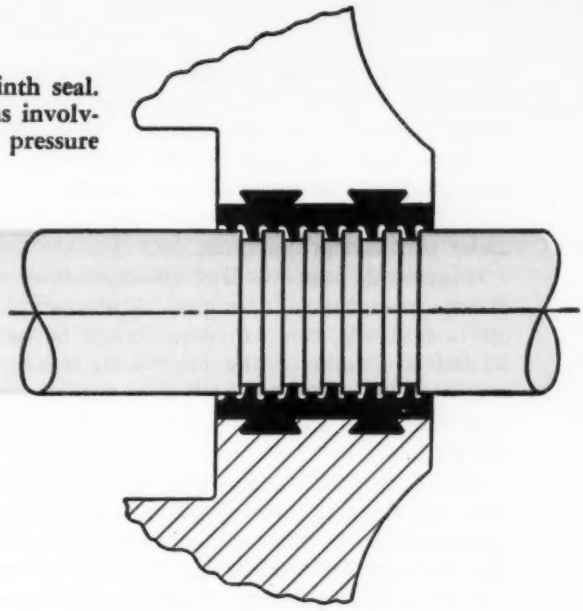


Fig. 2—Staggered labyrinth seal. Specified for applications involving moderate to high pressure

Pressure Gas

ter spring to the improved patented design shown in *Fig.* 4, in which the seal supports its own weight when the proper operating position has been reached. Wear is reduced and life increased.

The ring restricts leakage by dissipating gas pressure through the friction developed along its clearance walls. The principle is analogous to the pressure drop effected by friction through a long pipe of small bore. A well-designed labyrinth seal, occupying the same axial space would permit roughly four times as much leakage which is apparent in *Table* 1.

Pressure differentials as high as 150 psi may be obtained across each carbon ring. It is particularly applicable to flexible shaft machines since it is not seriously affected by the radial oscillations developed when the unit is passing through a critical frequency. Clearances are not increased as they would be in a labyrinth seal.

The segmental carbon-ring seal is also useful at high ambient temperatures. Under such conditions the clearances of a labyrinth seal increased allowing greater leakage. However, clearances of the carbon seal decrease as temperature rises because its coefficient of expansion is less than the coefficient of expansion of the shaft.

Application of the segmental carbon-ring seal, as an independent unit, is limited to compressors dealing with a clean gas. When the gas is dirty the carbon-ring seal may be used effectively in conjunction with other types of seals and systems, as described later.

Leakage permitted by the segmental carbon-ring seal is a function of clearances, gland width and

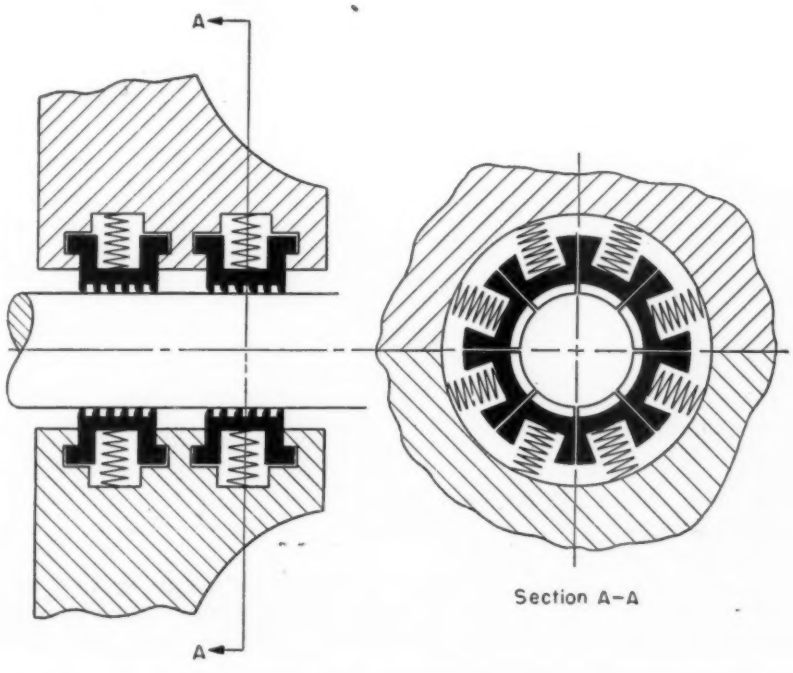


Fig. 3 — Segmental labyrinth seal. Design is efficient in handling high-temperature gases because clearance is little affected by thermal expansion

the number of rings for given gas properties and pressures. Design clearances are usually maintained through the run-in period. Thereafter, they increase more or less slowly depending on the amount of abrasive material contained in the gas. Seal life is, in general, about two or three years under continuous operation.

In general, temperatures are limited by the oxidizing properties of the gas. For example, when air is involved, temperatures should be below 600 F; 900 F should be the limit with steam. These seals can be used in compressors having shaft surface speeds of 15,000 feet per minute, or more, at the seal.

Most important advantages of segmental carbon-ring seal designs and labyrinth designs are ease of inspection and replacement. A cap is removed and the segmental elements can be slipped out.

Costs of carbon ring assemblies have been progressively reduced by a trend toward the standardization of rings. The gland box, however, in which the carbon rings are positioned, is ordinarily a design built to meet individual specifications and its cost will vary with the quantity ordered.

Bushing Seal: Although the segmental carbon-ring seal is, in principle, a bushing seal, attention is directed to other types of bushing seals for use in sealing both liquids and gases. For the sealing of liquids, long bushings have been used for many years as interstage seals in water pumps. They have also been used in combination with other seals in fluid-injection sealing systems for high-pressure gas compressors as will be described later. With lubricating oil as the fluid, the bushing offers almost indefinite life. However, with water, life depends upon the amount of particle contamination in the water and the ability of the design to maintain a sizable film clearance between shaft and bushing bore.

In principle, the bushing acts as a seal by reducing pressure through friction along the annular clearance walls. Entrance and exit velocity losses contribute in small order. Mechanically, the bushing must be permitted to float radially with the shaft, therefore requiring a lapped sliding joint on the face of the bushing with the stationary housing. Sometimes, where very small clearances between shaft and bushing are required, and where precise alignment cannot be maintained, the design must allow angular adjustment as well as radial motion. In these cases, a lapped spherical joint must be provided between bushing and housing.

Fluid bushings with L/D ratios between 0.5 and 2.0 and clearances of 0.100 to 0.200-inch per inch of diameter, sealing against 1000 psi of lubricating

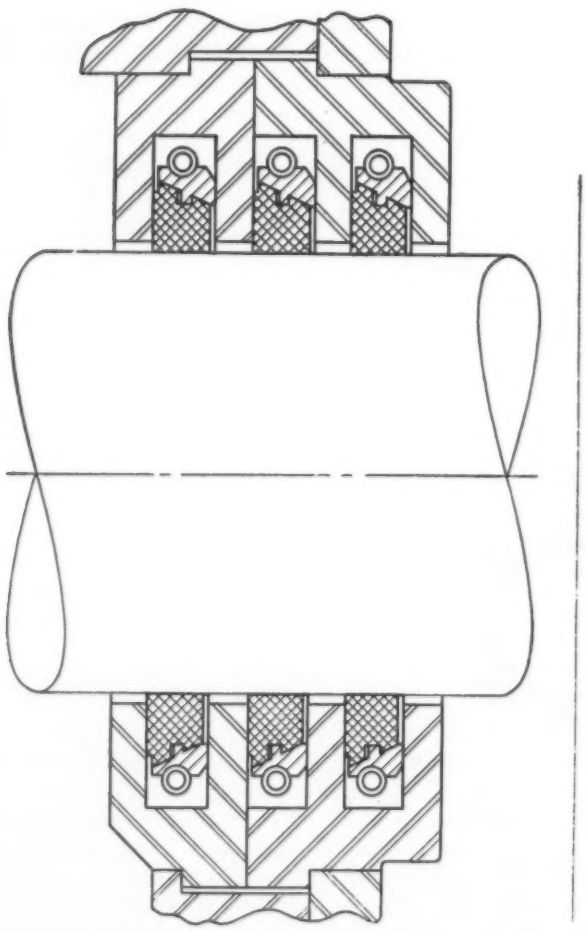


Fig. 4 — Left — Self-positioning type of segmental carbon-ring seal. Used extensively in steam turbines, the design provides tight sealing, conservation of space, and reduction of shaft length

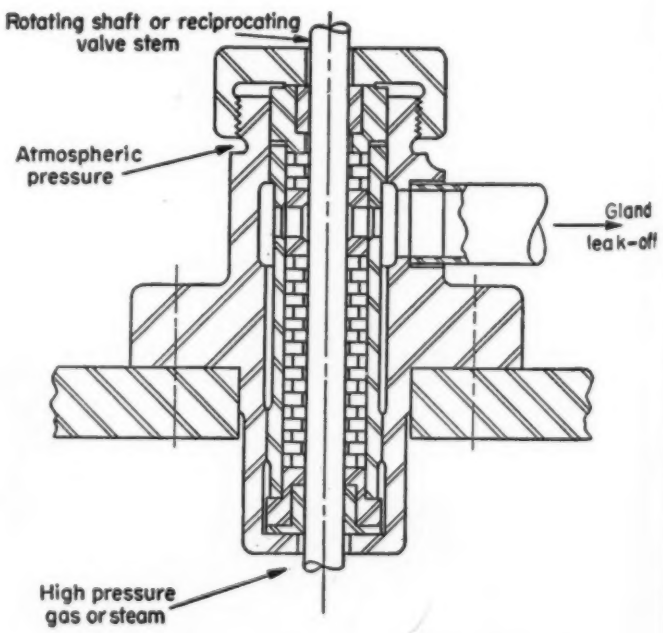


Fig. 5—Above—Multiple bushing or floating-ring seal assembly. Reduces clearance limitations inherent in long bushings

oil, will leak a few gallons per minute, even at surface speeds of 10,000 feet per minute. Bushings under the same conditions, but with clearances in the order of 0.0005-inch, will show as low as a few gallons per day leakage. In this latter case, extreme precaution must be given to provisions for proper support, cooling and filtering the fluid.

For the sealing of gas, a unique and effective bushing seal design developed by one of the seal manufacturers is shown in *Fig.* 5. In design this seal is essentially a long bushing which has been broken up into many small bushings or floating rings. It is recognized that clearance limitations with a long bushing primarily result from inherent errors in manufacturing and in alignment. Therefore a narrow bushing should lower these limits and offer reliable operation with clearances in the order of a few ten-thousands of an inch.

The design shown consists of alternately arranged floating rings having close clearances with the shaft and large clearances with the housing, and rings having large clearances with the shaft and close clearances with the housing all positioned within a suitable housing for the particular application. The design was first made for sealing turbine valve stems against pressures of 2000 psi and is now being developed for rotating shafts in many applications.

Contact Seal: A mechanical seal, the contact seal differs from labyrinth and bushing, or segmental ring seal, in that mating proximity between a rotating and nonrotating part is made possible under controlled mating pressures by springs. The design consists of a shoulder or collar fixed to the shaft, and a nonrotating seal ring positioned against the collar by springs. This nonrotating seal ring is free to float in both the radial and axial directions.

This basic arrangement, in more or less a crude form, has been used for many years as a fluid seal in centrifugal pumps. The dry-contact seal, *Fig.* 6, is a refinement of design. With particular attention to the control of mating pressures between stationary and rotating elements, it has proved its feasibility as a very effective seal for gases without requiring fluid lubrication or cooling.

The sealing elements are usually made of a refined grade of carbon for the stationary seal ring and a stabilized hardened steel as the rotating ring. This combination naturally would have similar temperature limitations as the segmental carbon-ring seal mentioned previously. Structurally, the carbon element should be given strength and rigidity

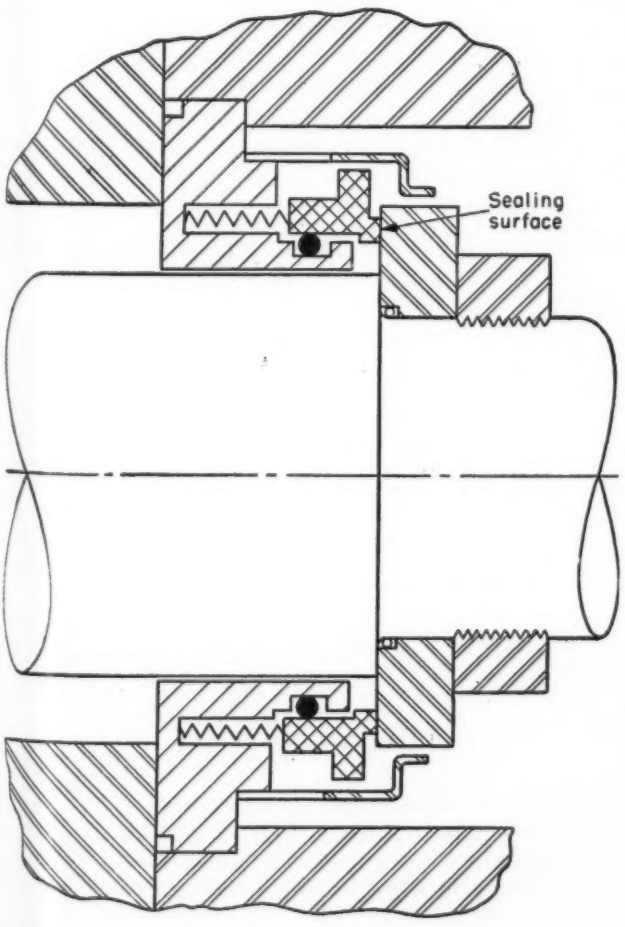


Fig. 6 — Left — Dry contact seal. Mating pressures are spring controlled. Nonrotating seal ring is free to float in both the radial and axial directions

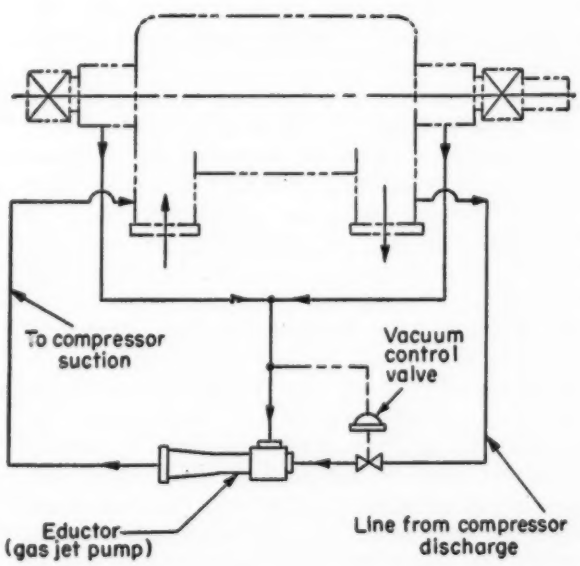


Fig. 7—Above—Centrifugal compressor with self-contained evacuation system which returns educted gas to compressor suction. Requires the use of two single sealing elements

such as by shrinking the carbon within a steel ring. The entire seal assembly should be arranged as a cartridge, thereby avoiding the necessity of handling the carbon element or damaging the many springs and other internal parts during shipment.

Designers are now selecting this seal for applications requiring strict limitations on leakage, either in or out of equipment such as compressors, and also where oil-sealing systems requiring external facilities and controls are not desirable. Successful operation in wind tunnel compressors with highly de-humidified air and in chemical process compressors have proved its outstanding advantages of effecting an almost perfect seal. Notice the leakage index of dry contact seal as compared to other seal designs in *Table* 1. It is almost unaffected by shaft vibrations. Wear in applications with a clean gas will be less than 0.001-inch per thousand hours offering a life expectancy up to three years of continuous operation. These seals have operated successfully with pressures up to 100 psi at surface speeds of 25,000 feet per minute and at pressures up to 400 psi at reduced speeds.

Refinements of this contact seal design for fluid applications such as with a SAE 15-30 lubricating oil have been proved in a large number of pipeline compressor applications with surface speeds up to 10,000 feet per minute, in combination with a bushing seal employing a pressurized fluid sealing system sealing gas at 1000 psi. Wear has been found to be less than 0.0006-inch per thousand hours, offering a life in excess of five years of continuous operation. The seal is able to withstand severe radial vibrations and axial shocks inherent in this service

Sealing Systems

Evacuation System: Shown in *Figs.* 7 and 8, is an evacuation system which requires the combined use of two of the single sealing elements: labyrinth, carbon rings or dry contact seals. It evacuates the gas from between the two seals, reducing the pressure below both the pressure of the compressor gas at the seal and the atmospheric pressure. No compressed gas escapes to the atmosphere at the compressor. Air would, of course, penetrate the educted chamber from the atmosphere and contaminate the compressed gas being blown off to the eductor. Depending on whether contamination may be permitted, educted gas is either returned to the compressor suction, *Fig.* 7, or wasted by expulsion to the atmosphere through a flare pipe, *Fig.* 8.

Whether the labyrinth, carbon ring, or dry contact seal is selected is determined by the permissible in-leakage of air, the need for recirculation of gas leakage, abrasive particle content of gas, speeds, pressures and temperatures. The eductor may be operated either by some external means such as air or steam, or by velocity ejector employing pressurized compressor discharge gas. In either case, the loss of horsepower which is incurred by recirculating gas, upon which work has been expended, must be minimized. In typical cases, this loss may account for 2 to 6 per cent of the power required to drive a compressor, for example, depending on gas pressures and characteristics, and the size of the installation. Obviously, reducing leakage by using carbon rings or dry contact seals would diminish this power loss. The principal advantage of the eduction plan is that it does not require a high capital investment, and it offers the possibility of a self-contained system relatively free of moving parts.

Gas Injection System: A typical gas injection system is shown in *Fig.* 9. Double labyrinth sealing elements are usually employed. Other combinations of the single seals previously discussed have also been used, contingent on the amount of injection gas which may be allowed to leak to the atmosphere and into the compressor.

The gas injection system functions by injection gas, such as an inert combustion product (carbon dioxide and air) or nitrogen, between two sealing elements at a pressure slightly higher than the compressor gas so that the injected gas leaks into the compressor and no compressor gas is able to leak into the atmosphere. The principle is particularly adaptable with the contact seal since the injected gas may be conveniently filtered.

The gas injection system has been used by the finery industries to totally seal flammable and toxic gases. Recent installations in the chemical process

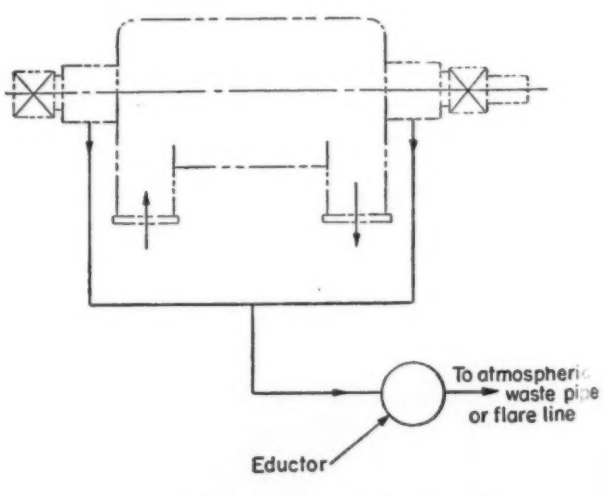


Fig. 8—Centrifugal compressor with an evacuation system in which educted gas is expelled to the atmosphere. Here also at least two labyrinth, carbon-ring or dry-contact seals are employed

industries use the contact seal in conjunction with the carbon ring assembly shown in *Fig.* 10. Many thousands of hours of trouble-free service have been recorded to date.

Fluid Injection System: Shown in *Fig.* 11, the fluid injection system is a firmly established system accepted for high-pressure pipeline installations. This sealing system is now being employed on cat cracker gas applications. Historically, the plan has been employed for many years as the water seal for coke oven gas compressors where water is injected between two slinger, or segmental ring type sealing elements, at pressures slightly higher than the gas pressure.

Many designers favor this type of seal for high-pressure and refinery applications since it is inadvisable to employ a dry seal. Combinations of two single sealing elements are employed such as contact seals, bushings, or even segmental carbon rings used as fluid seals. The injected fluid is usually oil, although other fluids may be used as dictated by specific requirements. The oil is filtered, cooled and pressurized to a pressure slightly above that of the gas pressure. Oil leakage usually takes place through both the atmospheric and gas sealing elements and is reclaimed and returned to the reservoir. In pipeline and other applications where the oil leaking to the gas side is not seriously affected by the gas, the oil may be used over and over again until the neutralization number indicates it has been spent. In rare cases, where the oil is exposed to a stronger toxic or sulphur gas, it may be discarded or reclaimed by outside facilities. If the seal on the gas side is properly selected, the amount of exhausted oil would be small, representing no more than a few dollars a day. Two combinations of sealing elements used most frequently with this fluid injection system are illustrated in *Figs.* 12 and 13.

Designers may differ in their approach to selecting the sealing elements. One approach would be to evaluate the characteristics of each element for its specific function and location. For example, on high-pressure applications, the desirable location for the bushing element is on the more rigid journal bearing side of the combination where angular deflections are negligible and, at the same time, where appreciable oil leakages can be easily drained and collected and tolerated without exposure to gas. On the gas side, the contact seal

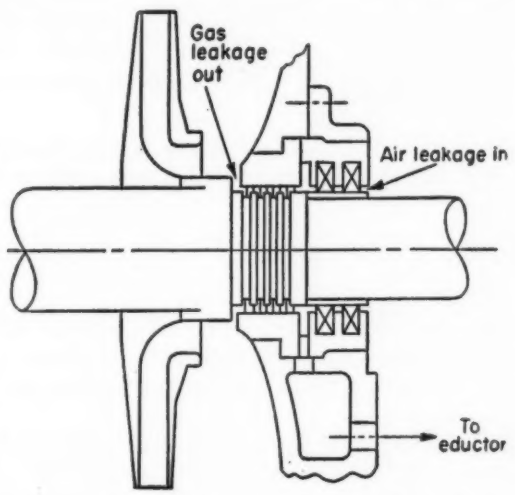


Fig. 10—Arrangement of labyrinth and carbon-ring seals for use with education systems

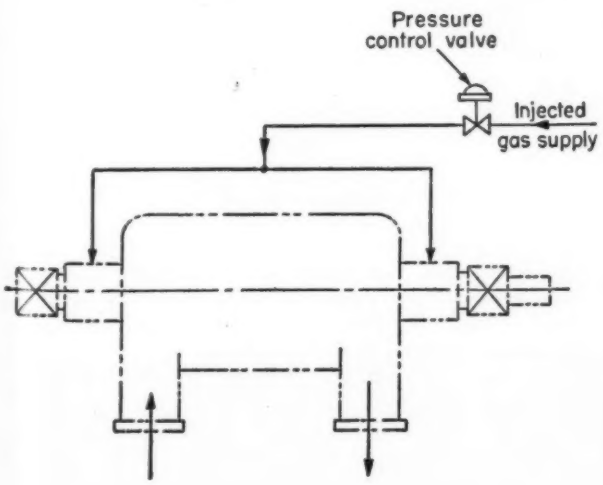


Fig. 9—Typical gas injection system. Double labyrinth sealing elements are usually employed although other combinations of single seals have been used

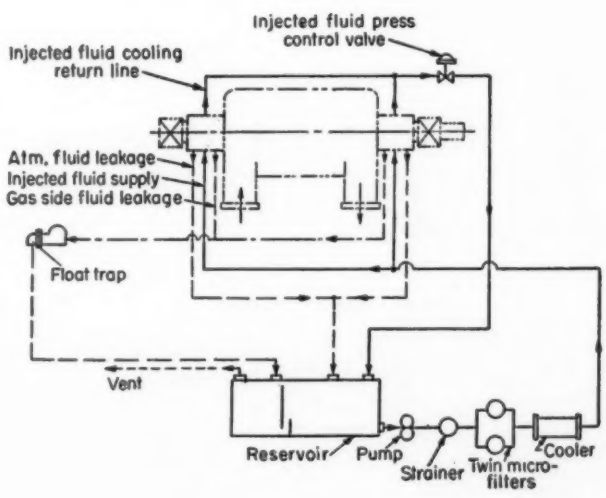


Fig. 11—Fluid injection sealing system. Some fluid, usually oil, is injected between two single sealing elements

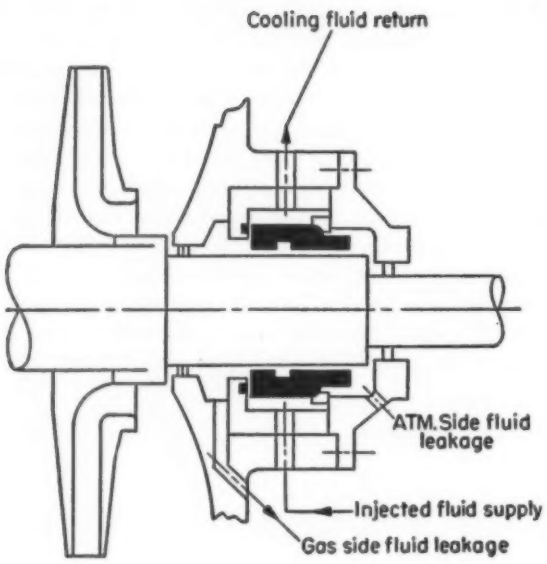


Fig. 12—Arrangement of integral double-bushing seal for use in fluid injection seal systems

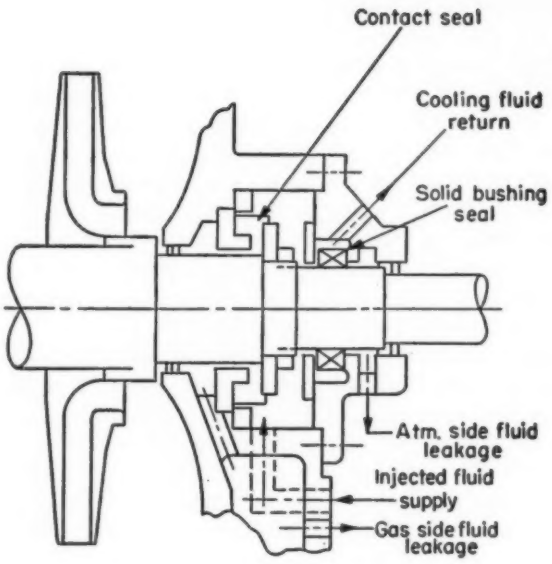


Fig. 13—Fluid injection sealing system employing double seals—contact and bushing types

may be preferred in view of its low leakage allowance and its insensitivity to shaft vibrations, particularly after machines have been in operation for some time.

Fig. 13 shows the injection system with a bushing and contact seal combined. Wear of the bushing on the atmospheric side, when ample rotating clearances are provided has been found to be negligible, and the life of the system is long. The contact seal also has an exceptionally long life. Wear measurements indicate a normal life expectancy of 50,000 hours before replacement of the carbon ring is required. The wet contact seal, like the dry contact seal, is almost unaffected by shaft vibrations and momentary rough operation. In addition, it offers reliable service under abnormal operating conditions where pressure of the injected fluid is not maintained above the level of the gas pressure.

There has been rapid progress in seal development over the past few years. However, it should be recognized that whatever the seal application may be, the designer must carefully interpret and analyze the available information. Therefore every effort should be made to clearly define the sealing requirements and specify as realistic limitations as possible.

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industrial design Ideas

you, you, you

HOPE you saw the recent Douglas Aircraft Co. ad with the headline *"The planes that don't try to redesign people"*. Then it went on to say "Design of every Douglas airliner starts at a single point—*you*".

We don't have to look far to see many products that could have been improved tremendously if their designers had only kept the *you* in mind. Not only should we designers know what our customers want before starting a new design, we should be sure to explore just how our customers will use (and abuse) the finished product. Are knobs and levers on your machine just right for women operators? What happens when Joe Messamuscle is assigned to that machine?

In the last few years, much research has been done on averaging the dimensions of the human figure — height, weight, reach, etc. Design your equipment for this "average" person. And that reminds me of a pet gripe—small screwdrivers have small handles and big screwdrives have big handles. I use all sizes, and somehow or other my right hand remains the same size!

—Cliff

Separable electrical connectors designed primarily for power-circuits have been discussed in the August issue of *Machine Design*. This article covers the selection and application of connectors for signal-circuit use, including coaxial cable types and a special group designed for use with printed circuits.

How to select and apply **Electrical Connectors** *for signal circuits*

By Laurence D. Shergalis
Assistant Editor, Machine Design

Fig. 1—Electrical connectors used in this typical aircraft radio installation permit easy replacement and testing of individual units

COMPLEX electronic calculators, business machines, aircraft instruments and control equipment are a few of the devices generally interconnected by many circuits. Code pulses, signal voltages, audio and thermocouple output voltages are among the variety of electrical signals passing between components of an electronic assembly.

Removable electrical connectors are often a necessity to facilitate assembly of the various components of electronic assemblies and to enable fast replacement and servicing of faulty units. Other advantages include interchangeability of subassemblies and ease of testing of completed units. Aircraft radio installation, *Fig.* 1, illustrates the use of separate electrical connectors in interconnecting a group of components. With the use of a connector, the microphone, *Fig.* 2, may be easily connected and disconnected, as conditions require.

These interconnecting circuits may be classified

as signal circuits as opposed to power circuits. While a definite line cannot be drawn separating power and signal circuits, the latter are usually characterized by their low currents, low voltages or a combination of both.

Voltages carried by signal circuits often range as low as a few microvolts. Currents encountered in signal circuits often lie in the milliampere region as compared to currents of several amperes or more carried in ordinary power circuits.

Because of their low power requirements, some electronic equipment and small motors may effectively utilize signal-circuit type connectors as connections to power sources. In other words, connectors of the signal-circuit classification need not be associated only with voice, video, telemetering and similar circuits, but may carry relatively light power loads as well.

Recently, the well known radio plugs and jacks, *Fig.* 3, have been miniaturized in keeping with the trend toward more compact electronic and electrical equipment. Three classes of signal-circuit connectors will be discussed in this article:

1. Multicontact connectors
2. Coaxial connectors
3. Printed circuit connectors

Multicontact Connectors: Signal circuit connectors with multiple contacts may be divided into two groups: (1) "AN" types and (2) other similar styles not bearing AN designations.

Electrical connectors of the AN type have been built to government specifications for the Armed Forces. Although AN type connectors have been designed especially for aircraft use, they are used on many types of equipment. Equipment using AN type signal-circuit connectors includes:

1. Mobile communication equipment including aircraft, police, taxi and marine radio equipment
2. Railroad communication and signaling equipment
3. Control circuits including regulators, flow con-

Fig. 2—Below—Flexibility in the use of microphones is gained by using a separable electrical connector

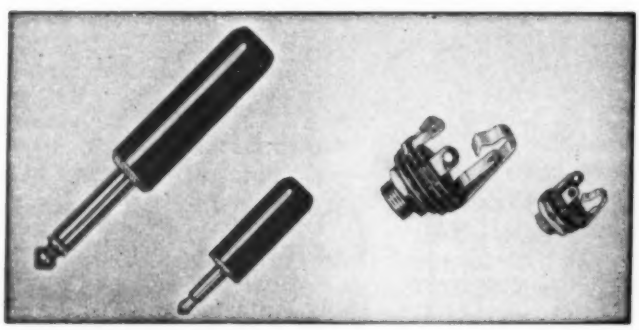
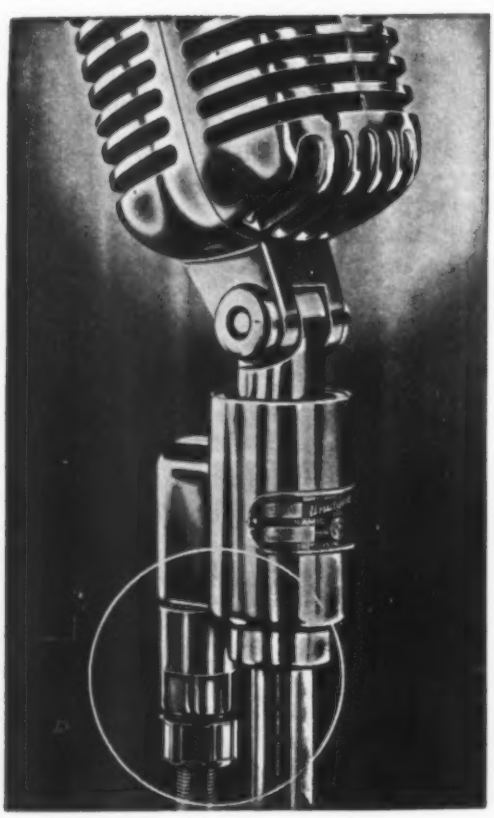


Fig. 3 — Left — Plugs and jacks of the type shown here are in common use in radio and telephone communication equipment

Fig. 4—Below—A variety of signal connectors of various sizes and shapes may be selected from nonspecification types, a few of which are shown here



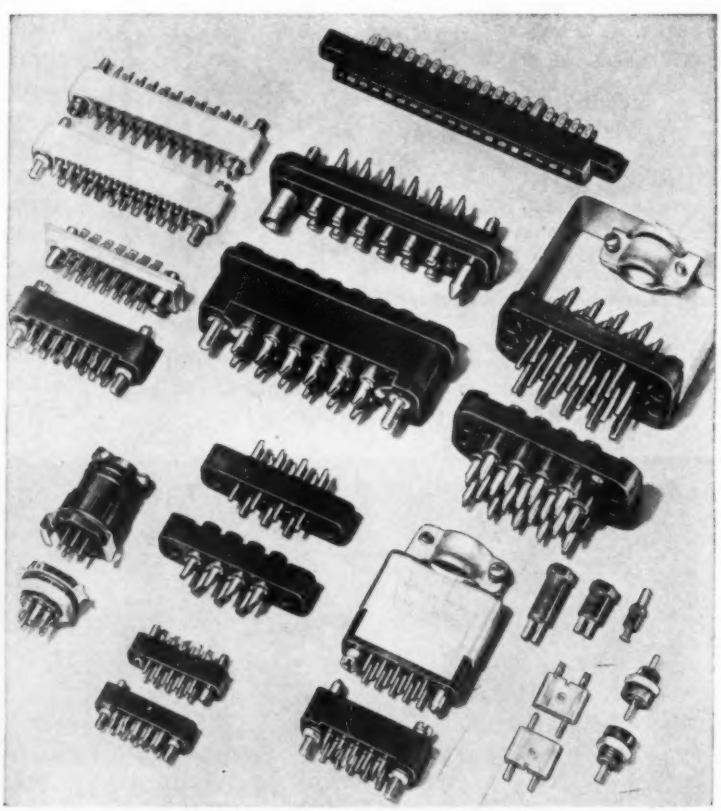


Table 1—AN Connector Numbering System

Shell		Insert	
Type	Design	Dia. (in.)	No.	Style
3100—Wall	A—Solid or one piece	8S–0.250	1	P—pin
3101—Cable	B—Split	10S–0.320	2	S—socket
3102—Box	C—Pressurized	10SL–0.320	3	
3106—Straight plug	E—Environmental	12S–0.448	4	
3107—Quick-disconnect plug	F—Vibrationproof	14S–0.525	to 11	
3108—Angle plug	K—Fireproof	16S–0.650	etc.	
	L—Waterproof	12–0.448		
	M—Moistureproof	14–0.525		
		16–0.650 to 48–2.550		

Example: AN 3102 A–16–11 P, AN box shell, solid, 0.650-inch insert diameter, number 11 insert, male pin style.

trols and combustion controls

4. Audio and video equipment including microphone and television cameras and associated components
5. Instruments including aircraft and industrial types
6. Electronic computers

Government specification MIL-C-5015 dictates the standards to which AN connectors are designed. The specification is reissued from time to time to incorporate latest design advances and is

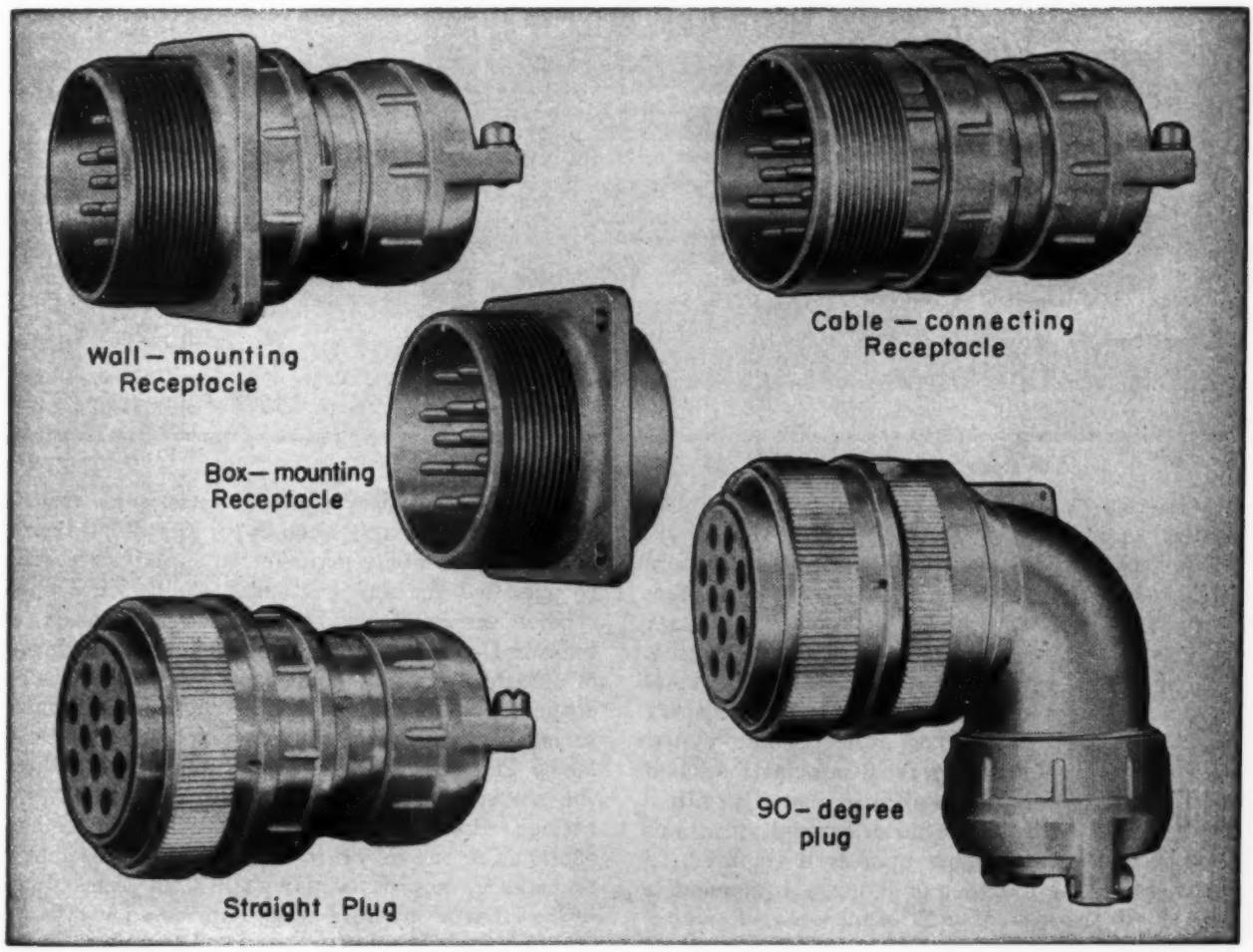
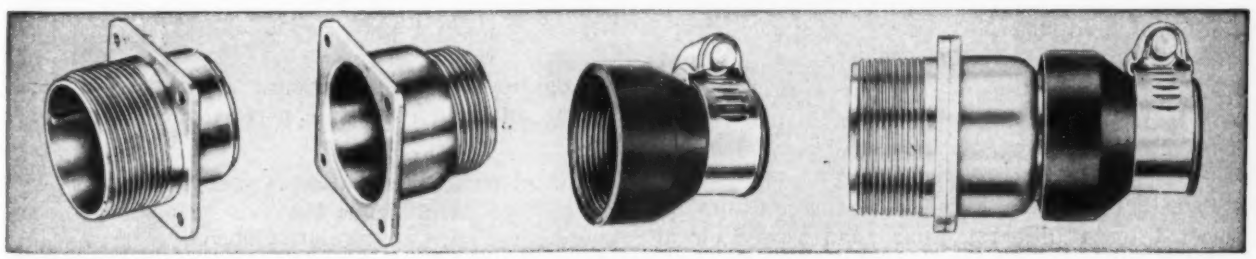


Fig. 5—Above—Shell designs available in the AN series. Specification code numbers are given for each style

Fig. 6—Below—How one commercially available AN connector is assembled. Three standard parts, left, make up the assembly, right. This connector may be made up to withstand most of the environmental conditions under which AN connectors are required to perform



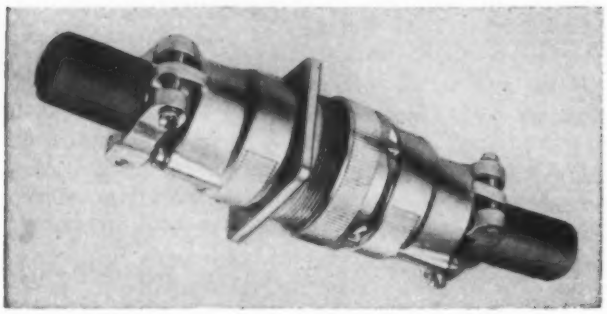


Fig. 7—Resilient material insulators, nylon grommets and telescoping bushings serve to protect this connector of the AN-E type from moisture. It also is capable of meeting requirements for operation at altitudes up to 70,000 feet

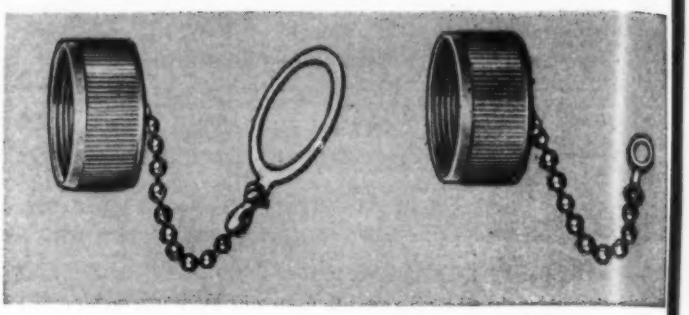


Fig. 8—Two types of dust caps and chain assemblies commonly available for AN connectors

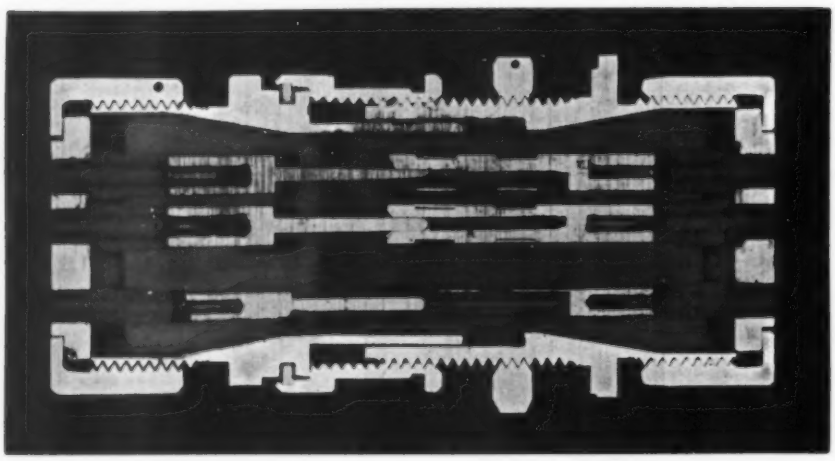


Fig. 9—Cutaway view of a connector designed especially to resist corrosive atmospheres commonly encountered in certain chemical processes. A compression nut on each connector, when tightened, effects an individual seal for each wire

also revised to meet more rigid operating requirements.

An important feature of all AN type connectors is their interchangeability, regardless of manufacturer. Shell size, insert size, contact size, contact spacing and coupling methods are all standardized.

Nomenclature has also been standardized. An AN connector part number may be made up to specify any of the approved types of any manufacture. Part numbers are made up from information listed in *Table* 1. Suffixes specifying insert position, finish, insert material and miscellaneous variations may be added to the part number if required.

Generally, the designer of military equipment is limited to the use of AN connectors. However, government approval is often given for the use of other types of connectors for specific applications. Where it appears that a particular nonapproved connector may give better service than an AN type, approval should certainly be requested.

Other types of signal-circuit connectors available include styles with round and rectangular inserts, *Fig.* 4. A large variety of inserts, mounting styles and locking methods are available. Factors to be considered in the selection of AN type connectors also apply to these similar styles.

Selection Factors: Signal-circuit connectors are selected on a different basis than power circuit connectors. Because a wide variety of inserts are available for any shell type, almost any combination of contact arrangements and sizes may be specified for any particular shell. Since shell type is governed by the proposed application, it follows that the intended operating environment is a logical starting point from which to develop connector specifications. After choosing a connector shell style, *Fig.* 5, for the operating conditions to be encountered, inserts may be specified for the proper number of circuits, voltage and current ratings. Some commercially available connectors, such as the one shown in *Fig.* 6, may be assembled to make up any particular shell style from standardized parts. Factors to be considered are:

1. Environmental conditions
2. Connector mounting
3. Number of contacts
4. Current rating
5. Voltage rating
6. Frequency
7. Utility

Environmental Conditions: Operating environment affecting connector performance includes:

1. Moisture
2. Temperature
3. Dust and dirt
4. Corrosive atmospheres

5. Explosive atmospheres
6. Rarified atmospheres
7. Vibration
8. Rough handling

MOISTUREPROOF connectors of the AN type, *Fig. 7*, combine two environment resisting characteristics. Designated type AN-E, these connectors are completely sealed against moisture and are vibrationproof. Development of this class of connector was prompted by rigid performance requirements of high-altitude aircraft. Applications for which the type E is intended are those where the connector will be subject to heavy condensation and rapid changes in temperature or pressure. Very high vibratory conditions may also be included.

Conductors and contacts are sealed against moisture by resilient grommets and inserts. Gasketed mating surfaces, sealing washers and accurately threaded coupling rings complete the seal.

Other styles of moistureproof and submersible connectors are available in nonspecification types. These styles are generally larger and heavier than their AN-E counterparts. Sealing, however, is accomplished in the same manner as in the AN types. Inserts of the AN type are available for some of these commercial types while others use specially designed inserts. Up to 52 contacts are commonly available.

TEMPERATURES at aircraft firewalls and similar locations may damage connectors not specifically designed for that service. Specification MIL-C-5015 provides two types of AN heat-resistant connectors. Type AN-K is specified for fireproof applications and type AN-H for flame-barrier applications.

Fireproof connectors, according to the specifications, are required to carry rated dc for 5 minutes when exposed to an open flame of 2000 F.

Flame-barrier connectors are required to withstand a 2000 F flame for 20 minutes, but circuits are not required to remain functional. Type H connectors when mated, are merely required to prevent passage of flame for 20 minutes.

Inserts of both types of high-temperature connectors are of ceramic material. Molded melamine, asbestos-filled, glass-filled or ceramic-filled materials are also used as insert materials. Gaskets are made of a high-temperature silicone rubber. To prevent soldered connection failure, solderless contacts are provided. These solderless connections may be either the crimp type or taper-pin type.

Shell material of heat-resistant connectors is steel, usually cadmium plated.

DUST AND DIRT may settle in the socket contacts resulting in poor electrical connections and undue wear of the contacts themselves. Certain critical circuits may be adversely affected by excessive voltage drops or electrical noise caused by dirty contacts.

If connectors are to remain disconnected for any length of time, they should be provided with dust caps. Both screw-on types and hinged caps are available. Cap and chain assemblies, *Fig. 8*, are available for all AN connectors and for microphone and other low-level circuit connectors.

CORROSIVE ATMOSPHERES such as salt spray or chemical fumes, will damage contact pins and sockets. Corroded contacts make poor electrical connections which result in noisy or faulty circuits.

Any sealed type connector will protect contacts against corrosion. The AN-E type is especially suitable for service in corrosive atmospheres. Similar sealed types are available that will also perform satisfactorily. Dust caps should be provided to protect the exposed contacts when the connectors are not mated. Corrosion-resistant connectors are also available with gold-plated contacts.

Connector shells should be protected against

Fig. 10—Hermetically sealed connectors are required on this Bendix Omni-Mag aircraft unit. Protective caps for the receptacles are shown in the foreground

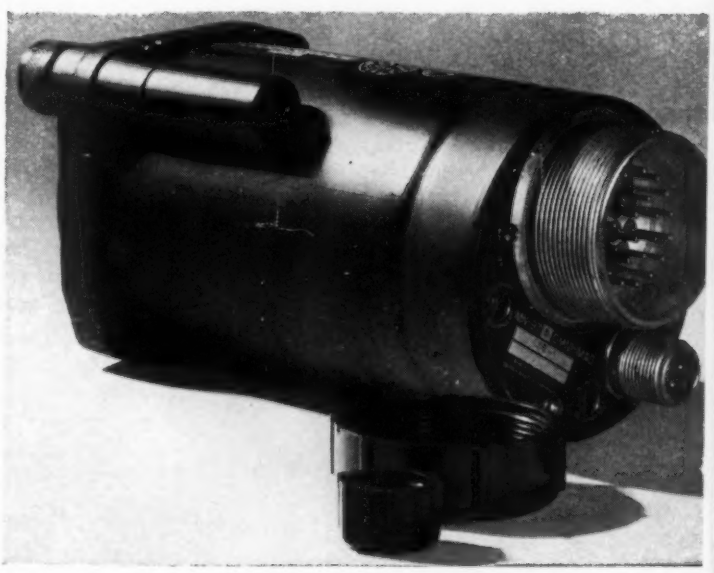
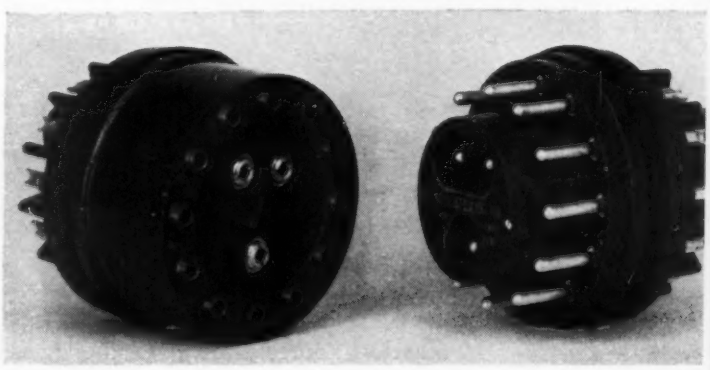


Fig. 11—Pressure-tight conectors shown here seal each contact with individual rubber rings



corrosion by suitable plating. Anodized, cadmium-plated and chrome-plated shells are available for corrosion-resistant connectors. A specially designed corrosion-resistant connector is shown in *Fig.* 9.

EXPLOSIVE ATMOSPHERES become dangerous if arcing occurs between loose connector contacts. Underwriters' Laboratories specifications for explosion proof connectors require a clearance between contacts and the insert, and between the insert and the shell of 0.0015-in. for a minimum length of ⅜-inch.

Connectors suitable for explosionproof service are available with contacts molded into the insert. The insert is a press fit into the shell. Inserts containing up to 47 contacts are commonly available in the explosionproof type.

RARIFIED ATMOSPHERES present problems of corona formation and flashover. Connector voltage ratings are usually reduced as atmospheric pressure drops. One solution to the problem is to increase contact spacing. Often this is not practical because of the necessity of accommodating a number of circuits in a limited space. In this case, sealed connectors should be employed.

Properly mated AN-E type connectors minimize trouble caused by condensation permitting full-rated voltage to be applied at high altitude.

Often signal-circuit leads must be brought out of an enclosed chamber in which pressure is higher or lower than atmospheric pressure. Certain aircraft instruments, *Fig.* 10, require complete sealing for proper operation at high altitudes. For these and similar applications, three classes of pressure-tight connectors are available: (1) pressurized connectors, (2) sealed connectors and (3) hermetically sealed connectors.

Pressurized connectors are designed to limit air leakage to no more than 1 cu in. per hr at a pressure differential of 30 psi. Either pin or socket

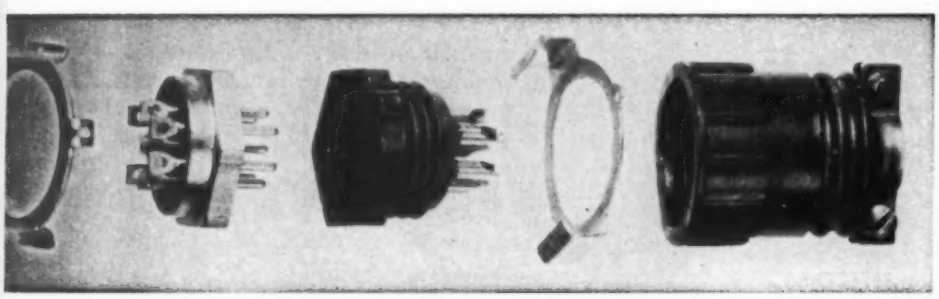


Fig. 12—Above—Exploded view of a hermetically sealed connector. Contacts are fused to a glass insert. A locking ring is provided to prevent accidental disconnect due to vibration

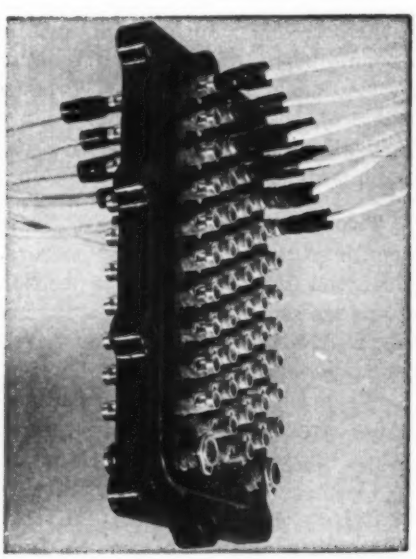


Fig. 13—Right—Electrical disconnect panel which may be mounted on a bulkhead separating pressurized compartments. Wires may be removed individually

Fig. 14—Below—Spring latch prevents this solderless contact from accidentally pulling out of its socket

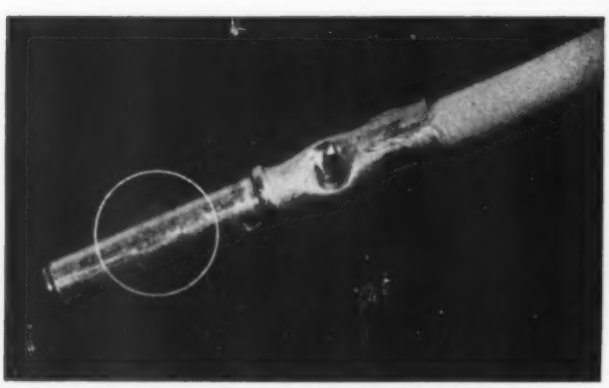


Fig. 15—Right—Threaded shells of these connectors accommodate locking rings

contact connectors may be pressurized. Pressurized AN type connectors are designated AN-C. Connectors may be sealed with synthetic rubber rings placed around each contact and between the insert and the shell. This arrangement minimizes alignment difficulties, yet assures positive sealing. One type of pressure-tight connector is illustrated in *Fig.* 11.

Sealed connectors are intended for use with hermetically sealed equipment where the leakage rate (tested with helium) must not exceed 10^{-5} cc per sec at a pressure differential of one atmosphere. This pressure must be maintained through a temperature range from −67 to 185 F. Sealed AN type connectors are designated AN-D.

Hermetically sealed connectors are permanently sealed to permit no leakage. Vitreous material used for inserts is fused directly to the shell and contact pins. Some hermetically sealed connectors are available to withstand high pressure sometimes encountered in underground applications. Contacts fused to a solid glass insert is a feature of

Fig. 16—Right—This mechanical latch arrangement serves to lock the connectors together and still allow rapid disconnecting if necessary

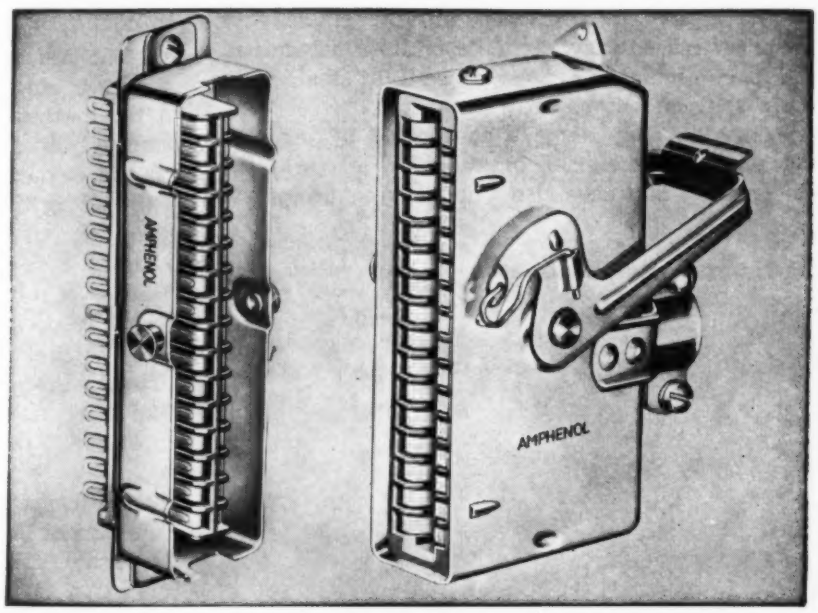


Fig. 17—Below—Two connector locking methods. A vibration spring, *a*, and the bayonet lock, *b*, guard against accidental disconnect caused by vibration or other means

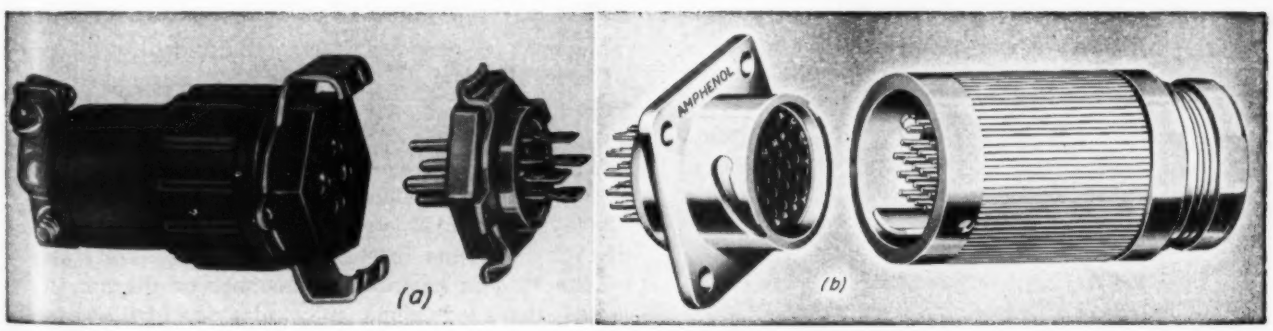
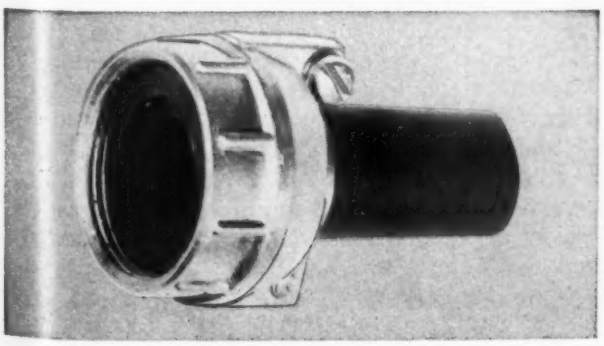
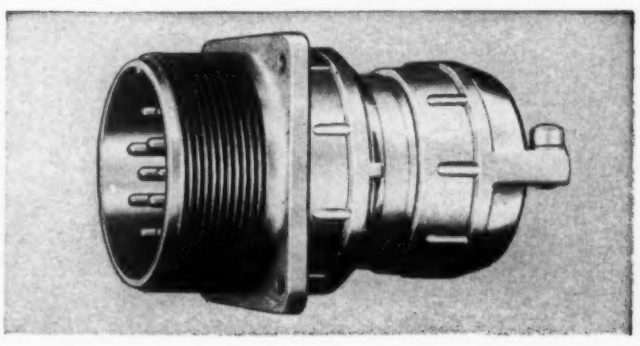


Fig. 18 — Typical cable clamp using a resilient sleeve that is forced around the cable to relieve strain on the socket contacts

Fig. 19 — Square mounting flange serves to hold the connector securely to the panel on which it is mounted





one commercially available hermetically sealed connector, *Fig.* 12.

Sealed instruments, relays, transformers or other miniaturized components require hermetically sealed connectors. Electronic high-voltage aircraft power supplies may be enclosed in an oil-filled box to prevent flashover at high altitudes. Hermetically sealed connectors would be necessary in this and similar applications to prevent oil leakage.

Another method of passing electrical circuits through pressurized bulkheads utilizes an electrical disconnect panel, *Fig.* 13. Individual wires are equipped with crimped-on pins and the pin inserted into the panel socket. A spring latch, *Fig.* 14, prevents accidental removal of the wire. However, the latch may be depressed and the single wire removed if necessary. Because of its construction, the panel maintains a pressure-tight seal, even when the conductors are removed.

VIBRATION may damage connectors by destroying the insert material, breaking the wires at the solder pots, and may also cause the connectors to pull apart.

Fig. 20—Box mounting connectors are open in the back to allow easy soldering of wires

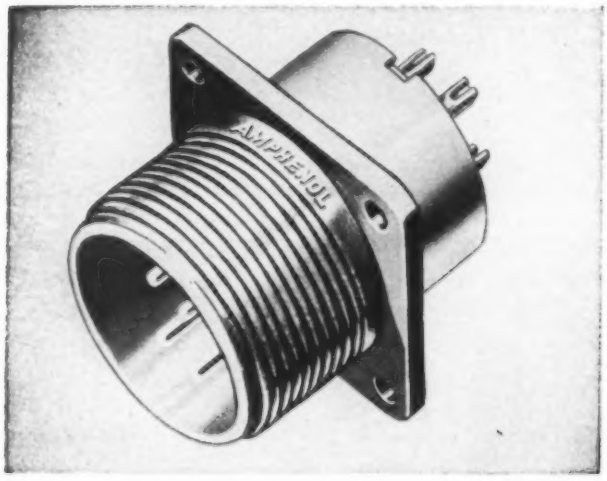
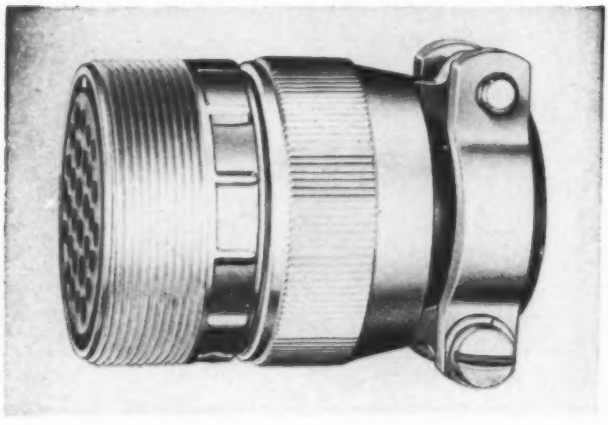


Fig. 21—A typical AN type female cable connector with cable clamp



Connectors designed to withstand damage to the insert usually provide some way of shock mounting the contacts. One method is to locate a rubber ring between the insert and the shell. A second method is to make the insert itself of a resilient material. Some type AN-E connectors are designed with resilient inserts while others provide inserts of nonresilient material that will withstand severe vibration. Various forms of solderless connections may be employed to reduce wire breakage.

Accidental disconnect of connectors due to vibration can be prevented by suitable locking means. Many locking methods are available. The proper choice depends upon how often the circuits may be uncoupled and the pressure or force necessary to couple or uncouple the connectors.

Most AN type connectors are provided with a coupling ring or nut mounted around the shell. After mating the connectors, the coupling ring is screwed on the mating threads of the other half of the connector assembly, *Fig.* 15. Contacts are pulled together or pulled apart by the action of the ring on the threads. Coupling ring thread sizes of AN type connectors range from ½-28 to 3-16. Coupling rings may be drilled for safety wires if desired.

A quick-disconnect type of lock is also available for AN style connectors. Where fast connect and disconnect are necessary, a spring-action ring is provided that slips over the mating threads and locks.

Another form of locking is provided with a mechanical latch, *Fig.* 16, that holds the connector halves together. This method is applicable where vibration is not so severe to warrant a threaded coupling ring. Latched connectors may be connected and disconnected quickly.

Bayonet locking, another common locking method permits fast connector coupling by merely twisting the plug after mating. Unlocking is accomplished with a reverse twist.

Square cut (Acme) threaded coupling rings are sometimes provided instead of the fine threads employed with AN type connectors. An advantage of Acme threads is that less than one full turn of the ring is required to connect or disconnect. Acme threaded rings may also be drilled for safety wires.

Many other types of coupling methods, *Fig.* 17, are available for special applications. Some of these types include gear train operated devices, cams and levers, and center post coupling. Larger connectors containing up to 500 contacts may require one of these special locking devices because of the effort required to couple or uncouple.

ROUGH HANDLING usually necessitates a heavy shell and means for protecting the contacts. Because the shell essentially protects the insert, it must withstand dents and scratches. Shells made of heavy steel are suitable for rough service conditions. Rubber shells will also take a certain amount of punishment.

Heavy plating of steel shells is necessary to

resist scratching and rusting. Cadmium plating is the most common method of protecting steel shells. External finishes such as chrome plating or nickel plating should be avoided where rough treatment is expected.

Cable clamps should, of course, be specified where the cable may be subject to severe strain. A clamp such as the one shown in *Fig.* 18, eliminates strain on the socket connections.

Connector Mounting: Methods of fastening connectors to panels, bulkheads or chassis depend upon available space and the mechanical layout of the unit. Shell styles of most signal circuit type connectors may be divided into four general classes:

1. Wall mounting
2. Box mounting
3. Cable connectors
4. Chassis mounting

WALL MOUNTING connectors, *Fig.* 5, are intended primarily to feed electrical circuits through bulkheads or firewalls. Pin or socket contacts may be supplied on both ends of the receptacle to accommodate cable plugs. Cables may also be terminated directly in a wall-mounting connector. In these cases, cable clamps and other necessary

Fig. 22—These multi-circuit connectors permit easy interconnection of components of an analog computer

Fig. 23—Rear of chassis mounting engages the connectors when the unit is slid into its compartment. The large guide pins assure accurate alignment

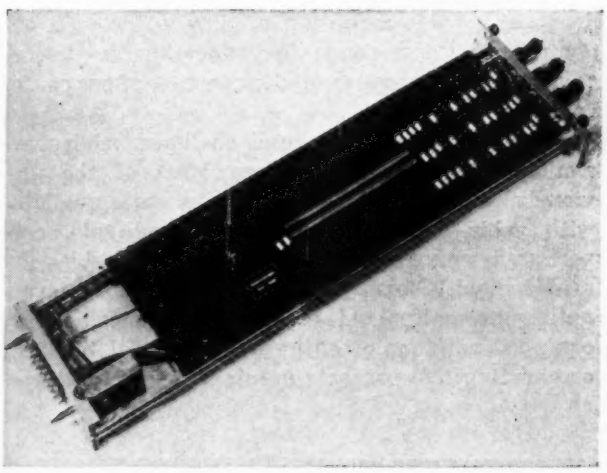


Fig. 25—Miniature chassis mounting connectors are available for small electronic units

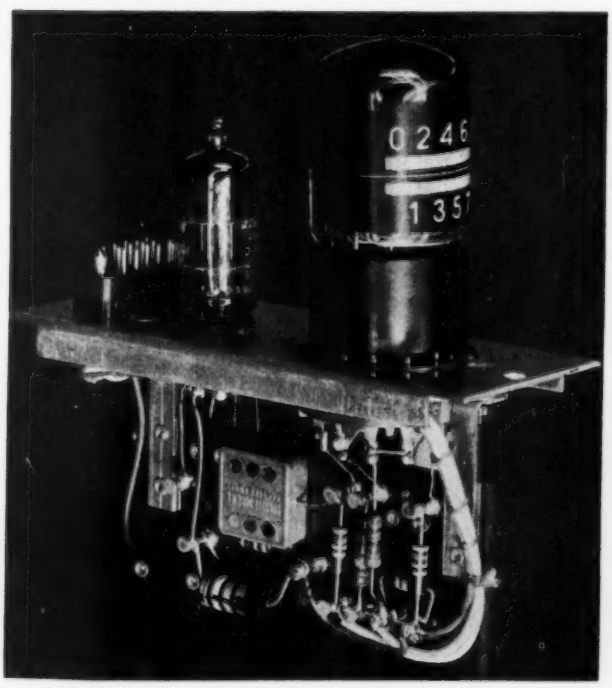
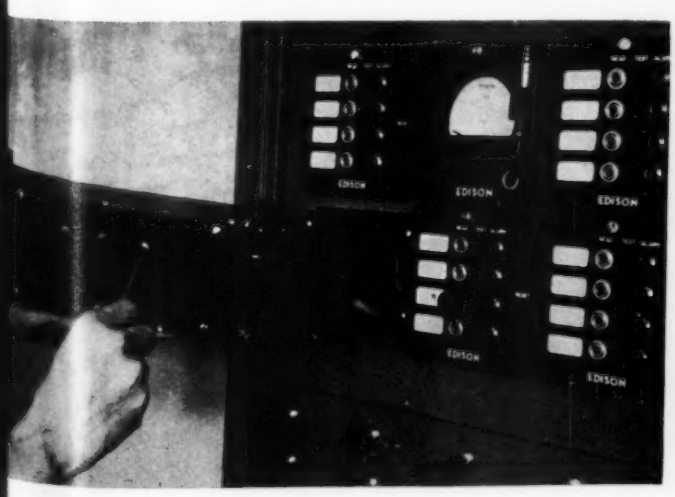


Fig. 24—A variation of the chassis mounting method permits adjustments to be made on the individual units while in operation



accessories are provided on the cable side of the connector.

A mounting flange, square for most AN types, is part of the shell, *Fig.* 19. Four holes drilled in the flange accommodate the mounting screws. Mounting hole diameters of commonly used AN receptacles range from 9/16-inch to slightly over 3 inches. Flange dimensions range from 7/8-inch square to 3¼-inch square.

Wall-mounting receptacles are usually fixed to the front of the panel. However, rear panel mounting connectors are also available where projections out of the front of the panel are to be minimized.

BOX-MOUNTING connectors are fastened to the equipment in the same manner as wall-mounting types. The back of the connector, *Fig.* 20, is open to permit easy soldering of wires to the contacts. Applications where wires to the connector come from many directions inside the box or chassis require box-mounting connectors. Junction boxes are an example of such an application.

CABLE CONNECTORS, *Fig.* 21 are used where space does not permit mounting of a receptacle on the equipment. Convenience in connecting or disconnecting cables may even dictate a preference for cable connectors.

Most AN type inserts and shell assemblies are available as cable connectors. Most of the previously mentioned locking means are available with cable connectors. As a general rule, connectors terminating normally energized cables are provided with female contacts while those terminating normally cold or de-energized cables are equipped with male contacts. Accidental touching or shorting live contacts is minimized if this practice is followed. Cable connectors used to interconnect components of an analog computer assembly are shown in *Fig.* 22.

CHASSIS MOUNTING of connectors is a convenient way of assembling electronic components without using cables. In practice, a plug assembly is mounted directly on the chassis, usually at the rear, *Fig.* 23. The mating receptacle is fastened to the rack in which the chassis is mounted. As the chassis is slid into the rack, the connectors mate. When the chassis is fastened in place with screws or other means, the connectors remain locked together.

Applications of this method include complex computer assemblies where many identical chassis are mounted in a rack. Faulty units may be removed quickly by removing the mounting screws and pulling the chassis out of its compartment. A variation of the chassis mounting method is shown in *Fig.* 24 and 25.

Most mounting styles, especially the AN types, accommodate a large variety of inserts. Where a large number of circuits will be required, enough mounting space must be provided to accommodate a larger connector. Appropriate inserts may then be selected for the number and type of circuits to be carried.

Number of Contacts: Because of the flexibility in the design of AN type connectors, inserts containing the proper number of contacts may, in most cases, be selected after basic connector usage and style have been determined.

Overall connector size, however, will be determined by the number of contacts to be provided. Choosing the proper insert is merely a matter of

Fig. 26—One style of a nonspecification-type connector that carries 208 contacts

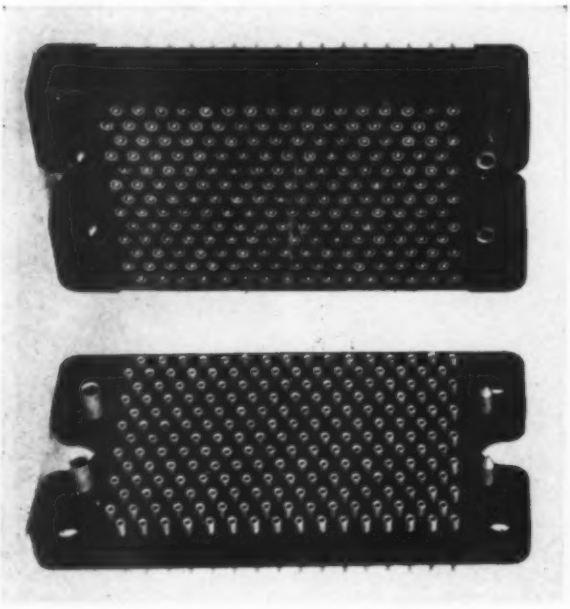
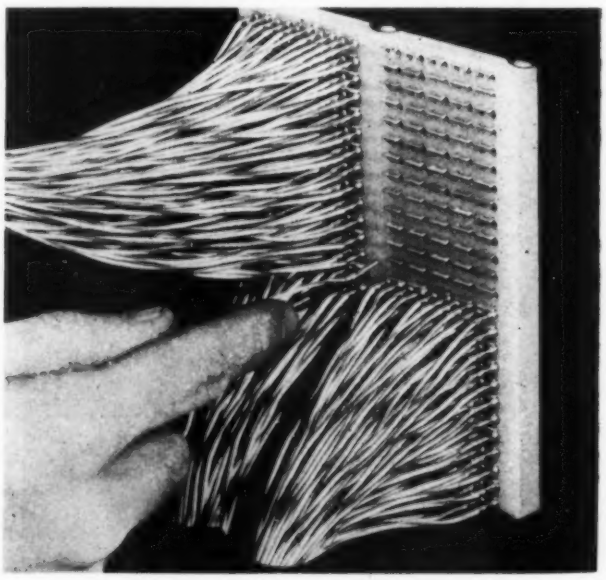


Fig. 27 — An example of the extremely large number of connector contacts that may be crammed into a relatively small space by using taper-pin solderless connectors



scanning the AN insert drawings and selecting the applicable insert.

Diameters of AN type inserts range from ¼-inch for single contact connectors to over 2½ inches for inserts containing up to 100 contacts.

Many combinations of contact sizes may be obtained in both AN types and non-specification types. Over 200 different AN type inserts containing combinations of small and large contacts, some with coaxial contacts, are available. Connector manufacturers usually list these inserts in the form of a chart giving the AN part number. Nonspecification types are available with an almost unlimited variety and number of contacts. The quick-disconnecting connector, *Fig.* 26, has 208 contacts rated at 5700 volts at sea level. It measures 3⅜ by 6$\frac{1}{16}$ inches.

Many types of solderless contact connections are employed to provide more contacts in smaller inserts. Crimped contact connections, of course, are in common use where high temperatures would melt soldered connections.

Two forms of solderless connections are available in which the individual wires may be removed if desired. One type wedges a tapered pin into a tapered hole in the plug or receptacle. Weight and space savings, *Fig.* 27, are realized with elimination of solder.

A second type of removable solderless connection, *Fig.* 14, employs a pin crimped to the end of each conductor. Inside the pin is an internal spring and spring-supported latch. After insertion into the contact, the pin locks in place. If necessary, the pin may be removed by depressing the spring-loaded latch.

Extremely critical applications may require rapid replacement of one faulty conductor. With removable solderless connectors, emergency replacement and repair are relatively easy. Tests have also indicated that solderless type contact connections perform as well as soldered types.

Current Rating: Overloaded connector contacts will overheat and may damage the insulating material. Arcing and burning between connector pins and sockets may result in severe damage to the entire connector and surrounding conductors.

Since current-carrying capacity depends upon the size of conductors, inserts having large enough contacts must be specified.

Current ratings for AN type connectors are given in specification MIL-C-5015. *Table* 2 lists the AN contact sizes and specified current ratings. AN connectors are rated up to 245 amp for normal service. Many nonspecification types are available in higher ratings in many different styles. These other commercially available connectors are

Table 2—Contact Ratings

Contact Size	Rated Current (Amperes)	Allowable Voltage Drop (Millivolts)
16 M	22	21
12	41	20
8	73	12
4	135	10
0	245	10

Contact size 16M replaces former sizes 16 and 20

Fig. 28—A miniature single-contact high-voltage connector assembly showing component parts

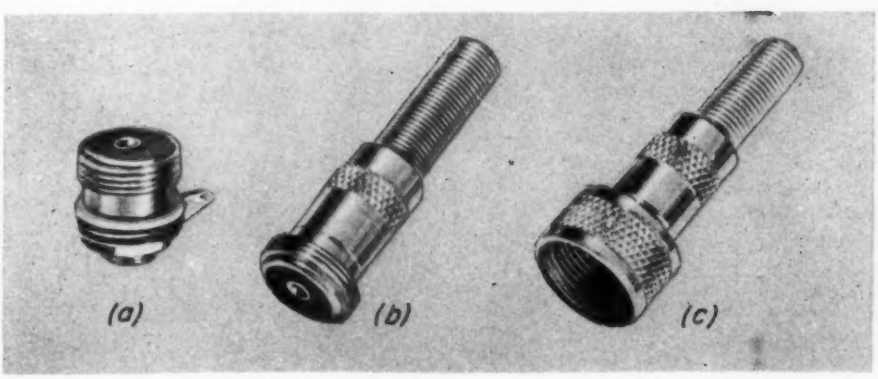


Fig. 29—Typical connectors designed for use at audio frequencies

rated as high as 1500 amp.

Contact material, as well as contact size, affects current rating. Steel has a high resistivity compared to copper and brass and will heat readily. Therefore, steel contacts must be rated considerably lower than copper. Aluminum and silver also have low resistivity and are good contact materials.

Voltage Rating: Maximum voltage that may be safely carried by a connector depends upon (1) spacing between contacts, (2) insulating material, and (3) contact arrangement. Minimum voltage depends upon contact resistance.

Mechanical spacing between contacts and the creepage distance (distance between contacts along the surface of the insulator) are related to voltage rating. Operating voltage specifications for AN type connectors are given in *Table* 3. AN insert drawings usually specify the type of service for which that particular arrangement is intended. From that information, voltage rating can be determined by referring to the table. Voltage ratings of other commercial connector types may be obtained from manufacturers literature. A typical miniature high-voltage connector is shown in *Fig.* 28.

Where connectors are to be used at high altitudes, care must be exercised in selecting the proper voltage rating. Corona formations at high altitudes tend to increase the possibility of arcover and effectively reduce ratings. Sudden temperature changes often encountered in high-altitude aircraft cause condensation, another factor affecting arcover ratings. Dirt on contacts will also reduce the effective spacing and increase the possibility of flashover.

Table 3—Contact Arrangement Service Rating

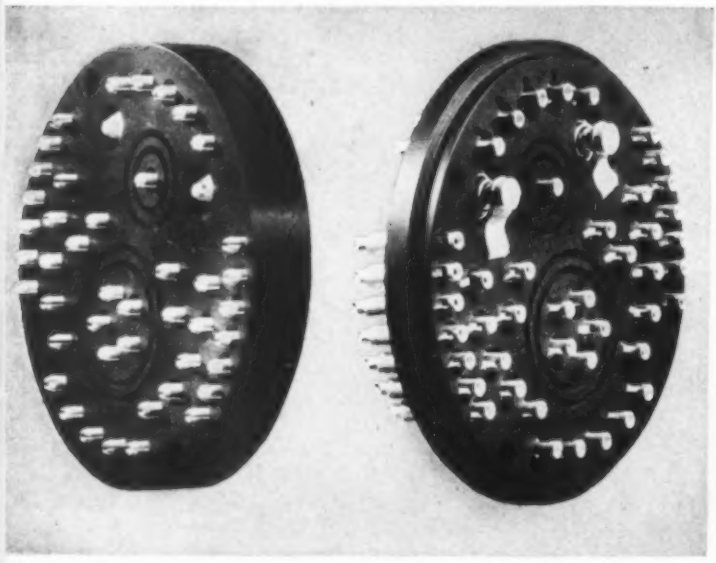
AN Service	Limit Operating Voltage at Sea Level (dc)	(ac rms)	Effective Creepage Distance (inch)	Mechanical Spacing (inch)
Instrument	250	200	1/32	..
A	700	500	1/16	1/32
D	1250	900	3/32	1/16
E	1750	1250	1/8	3/32
B	2450	1750	3/32	1/8
C	4200	3000	1	3/32

Fig. 30—Right—This subminiature connector may be specified for applications where space is at a premium

Fig. 31 — Extreme right—Quick disconnect is provided in the microphone connector by a latch type lock

Fig. 33—Explosive disconnect shown here is used where extremely fast uncoupling is necessary. One application may be found in launching guided missiles

Fig. 32—This 46-contact assembly may be disconnected quickly by electrical or manual means



Connector contact resistance introduces a voltage drop in electrical circuits carried by the connector. If contact resistance is too high, the resulting excessive voltage drop may reduce the signal to an unusable value.

Among the causes of excessive contact resistance are (1) contacts too small, (2) dirty or corroded contacts, (3) loose contacts, and (4) high resistivity of contact material.

Small contacts have a proportionately small contact surface area. Extremely low-voltage signals may be lost unless the contact area is great enough. Maximum allowable voltage drops for AN series contacts are listed in *Table* 2. For voltages below about 10 millivolts, something larger than the contact size 4 or 0 must be specified.

Dirt and corrosion can be minimized by specifying sealed connectors. Occasional cleaning is often required.

Contacts often loosen with wear. Usually the only cure is to replace the entire insert.

Contact material is an important factor in producing excessive contact resistance. Steel contacts, for example, have inherently high resistance. One effective means for reducing contact resistance is plating. Both silver plated and gold plated contacts are generally vailable.

Frequency: Alternating-current circuits operating at power supply frequencies generally need no special consideration as to shielding or capacitance between conductors. Common ac power frequencies range from 25 to 400 cps. However, audio frequencies ranging up to 15,000 cps often require shielding to avoid hum pickup, especially low-level circuits requiring a great deal of amplification.

Most commercially available connectors incorporate means for grounding the connector shell to the cable shielding. Cable shielding is generally braided, tinned copper and may be soldered to the connector shell. Where soldering to the shell is not feasible, a clamp arrangement may be provided to hold the shielding against the shell. In either case, the connector shell will act as a continuation of the shield to avoid stray hum or noise pickup at the connector contacts. The coupling rings also maintain the ground connection through the connector assembly. Microphone and audio circuit connectors, *Fig.* 29, are designed so that the cable shielding may be soldered to the outer shell.

Circuits operating at frequencies above the audio range require special consideration to minimize hum, noise and distortion. Coaxial connectors are especially adaptable to high-frequency service and will be discussed in a later section.

Utility: After selecting the proper connector style according to the preceding requirements, a modification may be necessary on the basis of the overall use. For example, a connector selected on the basis of electrical and environmental considerations may be too small to handle if the service technician must wear heavy gloves. On the other hand, it may be too large for the space available. A nonspecification subminiature type, *Fig.* 30, may be the answer.

Another modification may be necessary where emergency conditions may require extremely quick disconnect. Long threaded coupling rings would require too much time to uncouple. Bayonet or spring-latch locking mechanisms should be specified for any application in which circuits must be disconnected rapidly or frequently. The microphone connector, *Fig.* 31, features a latch lock coupling for quick disconnect.

Where extremely quick disconnect is necessary, special connectors may be used. A 46-contact

Fig. 34—Coaxial-type construction in which the inner conductor is surrounded by a tubular shield

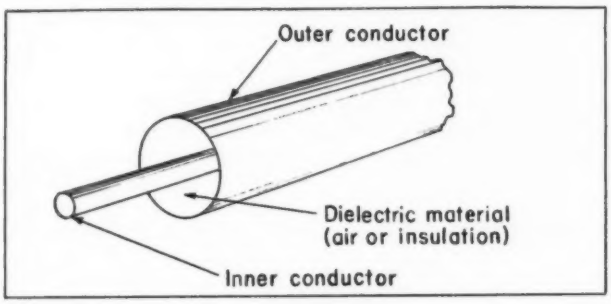
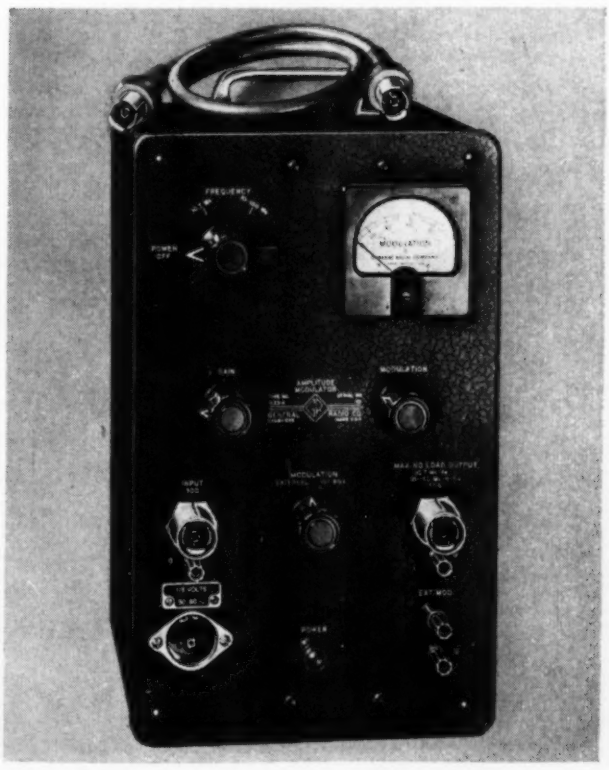


Fig. 35—Typical use of coaxial connectors with a test instrument. Connecting cable is shown on top of the instrument case



quick disconnect assembly is shown in *Fig.* 32. The force necessary is self-contained and may be actuated electrically or manually. Explosive disconnects find use in guided missile launching devices. A typical unit, *Fig.* 33, has 100 contacts and may be reloaded and reused.

Portable test panels are often designed to accept outputs of many types of signal generating devices or transducers. Thermocouples, strain gages and tachometers are a few of the various types of transducers that may be employed in test operations.

Of these types, thermocouples require connectors having special contacts made of the same materials as the thermocouple. Use of connectors with no regard for contact material would add dissimilar-metal junctions in series with the thermocouple with unpredictable results.

For removable thermocouple connections, connector inserts of the common thermocouple materials are available. A few of these materials include iron, constantan, Alumel, Chromel, copper, platinum and rhodium.

Summary: In the selection of a multicontact connector, it may be advisable to first consider an AN type. One advantage of the AN series is their interchangeability with any AN connector of any manufacture. A second advantage lies in their design according to military specifications.

However, AN connectors are by no means universally adaptable to any situation. An extremely large number and varieties of other multicontact connectors are commercially available. Many of these other styles may satisfy design requirements in situations where AN connectors might be a compromise.

Coaxial Connectors: Circuits operating in frequency ranges over about 30 megacycles are extremely sensitive to outside influences. Shielding, both electromagnetic and electrostatic, is especially important. Uniformly distributed electrical parameters are also necessary to good operation.

Coaxial lines, in which a center conductor is surrounded by a tubular shield, *Fig.* 34, have been found to be one of the most satisfactory ways to handle high-frequency circuits. Connectors for coaxial cable circuits are especially critical because of the possibility of introducing discontinuities in the line. Discontinuities usually cause electrical "reflections" which may result in distortion and a loss of power. Commercially available connectors, *Fig.* 35, are designed to minimize such discontinuities in the coaxial circuit.

Military specifications have been drawn for most coaxial connectors. These connectors are identified by a UG-/U number. Each is designed for use with a particular coaxial cable type.

Selection Factors: Since coaxial connectors are inherently single-circuit, selection is based pri-

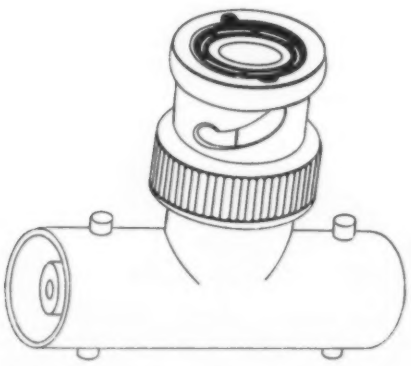


Fig. 36—Left—Tee adapter for coaxial connections

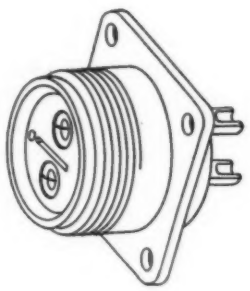


Fig. 37—Right—Twin-contact coaxial connector of the N series

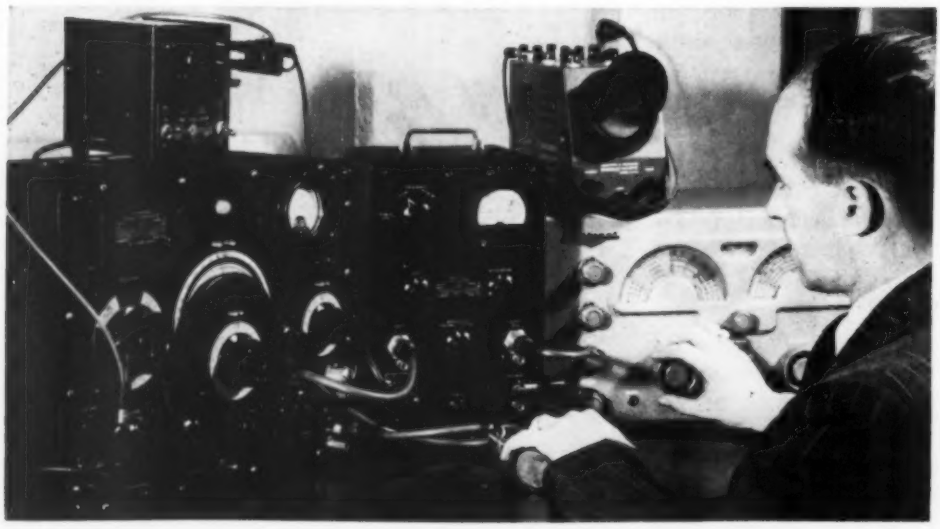


Fig. 38 — Laboratory test setup illustrates the use of coaxial cable connectors

marily upon factors relating to the electronic design of the circuit and environmental conditions.

Output impedance and power output of high-frequency electronic equipment are, of course, a function of the electronic design. Consideration of both these factors is one step in the selection of a coaxial connector.

After the field of selection has been narrowed by consideration of electronic design factors, a particular connector may be chosen from a category which fulfills requirements of environment and size.

Whether to select a coaxial connector on the basis of electronic design requirements followed by environmental and mounting requirements, or vice versa, depends upon the circumstances of the individual design problem.

Military Types: Several series of connectors have been developed for use with military equipment. This group includes both weatherproof and nonweatherproof styles, high and low-voltage types, and two series featuring quick-disconnect means. All of the commonly used mounting styles are also available. *Table* 4 lists the common military-type coaxial connectors with their more important characteristics.

Special attention must be given to the electrical characteristics of coaxial connectors. Catalog list-

Table 4—Military Series Coaxial Cable Connectors

Series	Recommended Rating (peak volts)	Recommended Operating Frequency Limit (megacycles)	Characteristic Impedance (ohms)	Weatherproof	Quick-Disconnect	Applications
BN	250	200	*	Both	No	Small, lightweight for smaller coaxial cables
BNC	500	3,000	50	Yes	Yes	Small with bayonet-lock coupling. For small cables
BNC Improved	500	10,000	50	Yes	Yes	Same as BNC but modified to operate at higher frequencies
C	1000	10,000	50	Yes	Yes	Bayonet locking with an improved cable clamp for better sealing
HN	5000	10,000	50	Yes	No	High-voltage
LC	5000	10,000	50	Yes	No	Large connectors designed for transmission of large amounts of radio-frequency energy
N	500	10,000	50, 70	Both	No	Low-voltage connectors for microwave applications
SM	100	1,000	*	No	No	Small, lightweight for small cable
UHF	500	200	*	No	No	Small single and twin contact general purpose connectors

*Nonconstant impedance

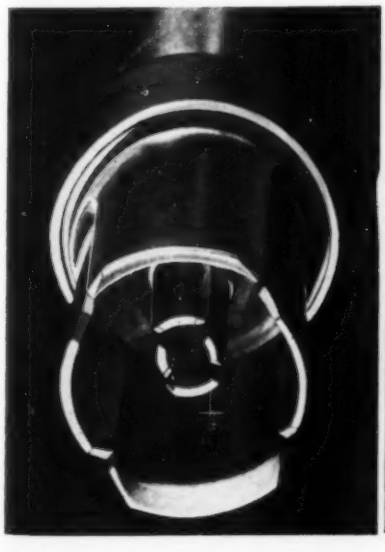
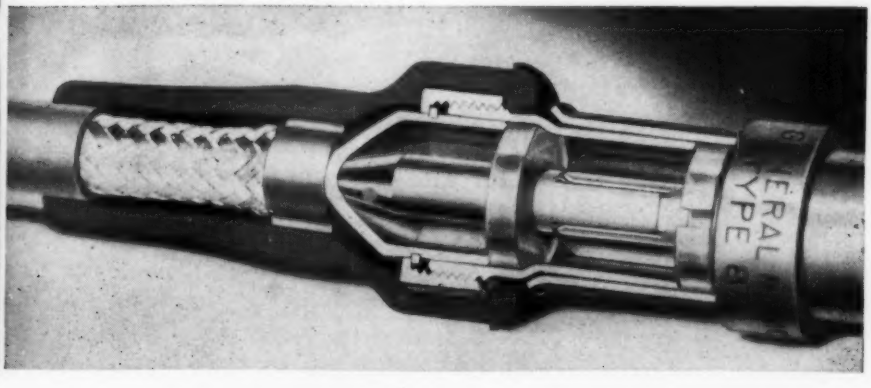


Fig. 39—Left—Both male and female halves of this coaxial connector are identical

Fig. 40—Below—Drawing showing how the identical male and female coaxial conectors mate



ings of these military types always specify a group of coaxial cables for which each connector is designed. Therefore, if a cable type has been specified, the proper connector may be chosen from the listing. Connectors of more than one series usually accommodate one particular cable type, thus permitting a wider choice based on environmental conditions and physical size.

Adapters to permit interconnection between different series connectors are also available. Various types of couplings, angle adapters and tee adapters, *Fig.* 36, give a great deal of flexibility in the choice of a connector. A twin type coaxial connector, *Fig.* 37, is available in the N series.

Test instruments may be equipped with one connector type capable of being coupled to other equipment having several different styles of receptacles or plugs. In this way, one instrument may be adapted to test a number of different operating units.

Other Styles: Many nonspecification types of coaxial connectors are also available. Laboratory equipment, *Fig.* 38, for example, generally requires connectors made to closer electrical tolerances than that required for many other types of equipment. Other special styles include subminiature and "microminiature" types for special applications.

One interesting commercially available connector features identical male and female units, *Fig.* 39. Its design eliminates the need for specifying separate male or female plugs or receptacles.

Both the inner and outer conductors of this type consist of tubing having four longitudinal slots. When mated, *Fig.* 40, the quadrants of one connector overlap those of the other. This mutual overlapping results in solid circular conductors. Adapters have been designed to permit interconnection with various military series as well as making the coaxial system adaptable to binding posts. Characteristic impedance of these connectors is 50 ohms with a recommended top frequency rating of 4500 megacycles.

One commercially available miniature type features a plug having an outside diameter of $\frac{3}{10}$-inch. Either push-on and screw-on styles may be specified.

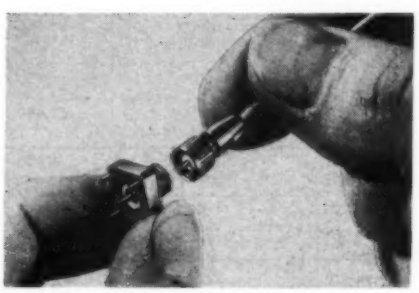
Another type especially adaptable to miniaturized equipment will accommodate a coaxial cable of 0.060-inch diameter. It may be obtained in pressurized, quick-disconnect and screw-on types. Color television camera connector, *Fig.* 41, accommodates three coaxial circuits in addition to 21 contacts.

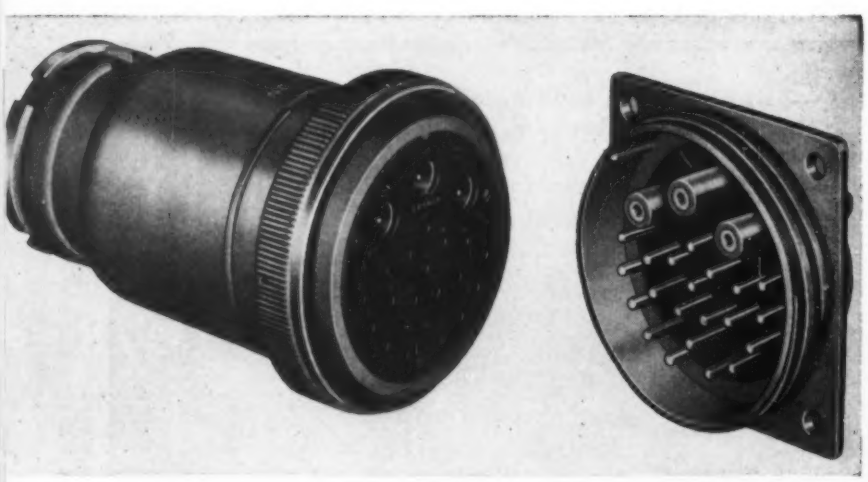
Obviously choice of a coaxial connector is greatly limited by the electrical characteristics of the electronic equipment. However, within that limitation, many types are available to fulfill other requirements imposed by operating conditions.

Printed-Circuit Connectors: Printed-circuit boards

Fig. 41—Below—Color television camera plug and receptacle with three coaxial connections in addition to 21 signal-circuit contacts

Fig. 42 — Right — This miniature connector is designed to be mounted on a printed-circuit board by dip-soldering





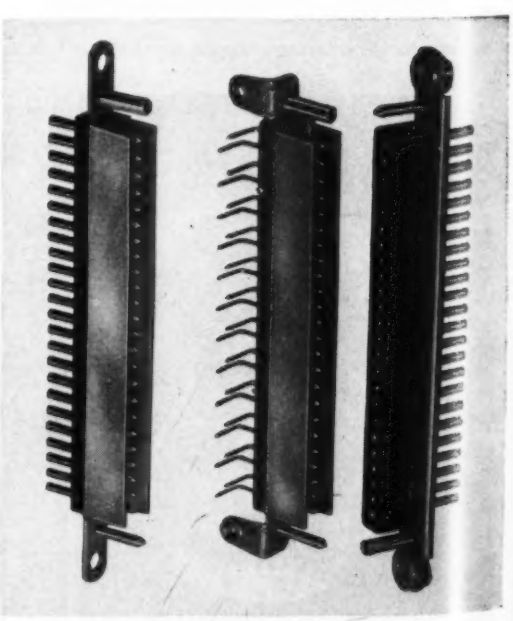


Fig. 43—Right—Connector for use in computer applications is designed to be mounted by dip-soldering techniques

require connectors of special design. Because equipment utilizing printed circuits has usually been designed to be as small and compact as possible, component parts, including connectors, should also be relatively small.

Another consideration involves the method of assembling printed circuit equipment. Dip soldering, usually employed in the assembly process requires a connector equipped with lugs enabling it to be mounted using that method. The miniature coaxial connector, *Fig.* 42, is mounted by five terminal points. Mounting base of the receptacle is 7/16-inch square.

Designed for computer applications, the 90-degree printed circuit plug, *Fig.* 43, can also be attached to the printed-circuit board by dip soldering. Polarization is accomplished by reversing one guide pin.

Another method of making electrical connections to printed-circuit boards is the card receptacle, *Fig.* 43. Here the board is slipped into the slot and engages spring contacts. Polarization may be accomplished by removing one contact and inserting a blanking stud in its place. A slot must then be provided on the board to permit insertion into the connector.

Single wires may be connected to printed-circuit assemblies by means of the miniature connector illustrated in *Fig.* 45. Having a current carrying capacity of 1 ampere, this connector may be easily connected and disconnected. Its diameter is less than $\frac{1}{8}$-inch.

Because of their relative newness, printed-circuit connectors are not available in as many varieties as conventional styles. For the most part, their application is in computer and miniaturized equipment not usually subject to severe operating conditions. Certain factors in the design of a printed-circuit assembly may possibly be dictated by the connectors that are available.

ACKNOWLEDGEMENT

MACHINE DESIGN acknowledges with appreciation the co-operation of the companies listed in the previous article on power connectors and the following companies in the preparation of this article on signal connectors:

Aircraft Marine Products Inc. (*Fig.* 27) ..... Harrisburg, Pa.
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American Phenolic Corp. (*Figs.* 16, 17, 20, 37) ..... Chicago, Ill.
Beckman & Whitley Inc. (*Fig.* 33) ..... San Carlos, Calif.
Burndy Engineering Co. Inc. (*Figs.* 13, 14) ..... Norwalk, Conn.
H. H. Buggie Inc. (*Fig.* 42) ..... Toledo, Ohio
Cannon Electric Co. (*Figs.* 2, 7, 10, 31, 41, 44) ..... Los Angeles, Calif.
Dage Electric Co. Inc. (*Fig.* 36) ..... Beech Grove, Ind.
DeJur-Amsco Corp. (*Figs.* 4, 12, 17, 30, 43) ..... Long Island City, N. Y.
Elco Corp. (*Figs.* 22, 23) ..... Philadelphia, Pa.
General Radio Co. (*Figs.* 35, 38, 39, 40) ..... Cambridge, Mass.
Gorn Electronics ..... Stamford, Conn.
Harvey Hubbell Inc. (*Fig.* 45) ..... Bridgeport, Conn.
North American Phillips Co. Inc. (*Fig.* 25) ..... Mt. Vernon, N. Y.
Scintilla Div., Bendix Aviation Corp. (*Figs.* 5, 8, 18, 19, 21) ..... Sidney, N. Y.
Switchcraft Inc. (*Figs.* 3, 29) ..... Chicago, Ill.
Thomas A. Edison Inc. (*Fig.* 24) ..... West Orange, N. J.
Titeflex Inc. (*Fig.* 9) ..... Newark, N. J.
Whitney Blake Co. (*Fig.* 6) ..... New Haven, Conn.
Winchester Electronics Inc. (Figs. 11, 26, 28, 32) ..... Norwalk, Conn.

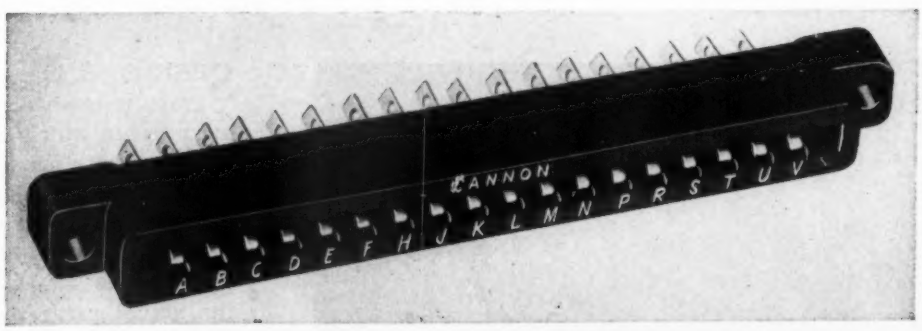


Fig. 44—Card receptacle type of connector accommodates a printed-circuit board in the slot. Spring contacts make the electrical connection between the connector and the printed circuit

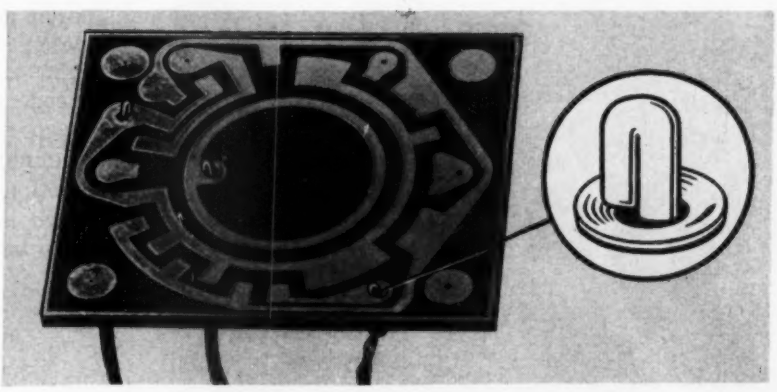
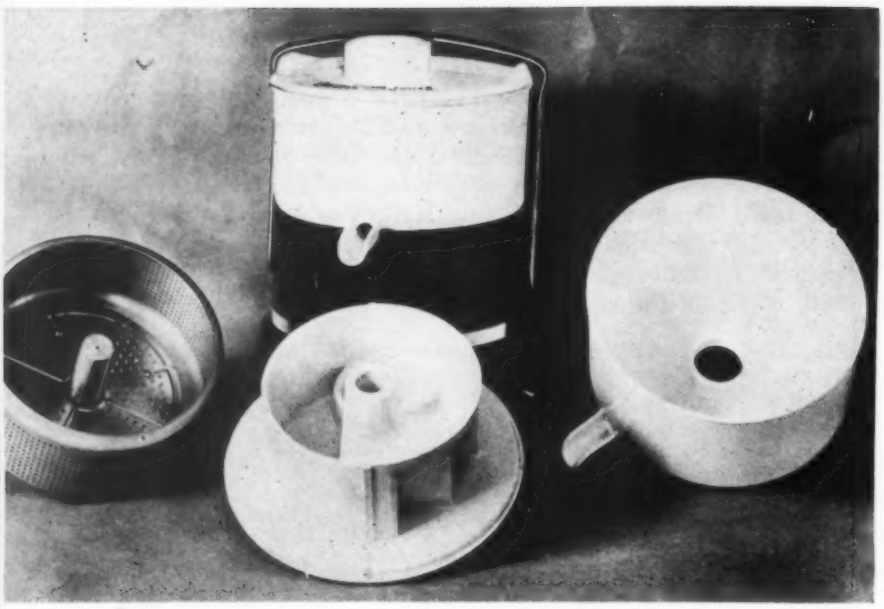


Fig. 45—Single-circuit connectors of this type are available to make separable connections to printed-circuit boards

Juicer Uses Many Plastics Parts



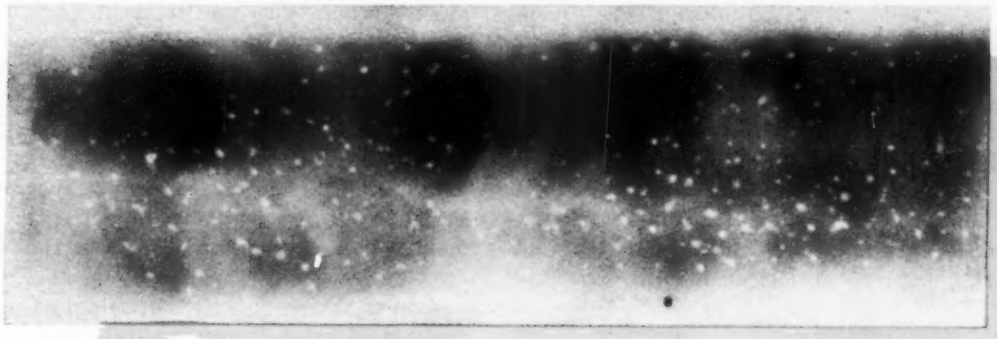
BLACK shock-resistant base in an improved Sweden Speed Juicer is a 4¼-lb compression molding of Bakelite phenolic plastic. Juice bowl is a 1-lb Tenite acetate-butyrate injection molding which resists cracking, crazing and weathering. The automatic feed and cover unit is a 3½-lb compression molding of urea thermosetting plastic. This part replaces a four-part assembly consisting of two plastic moldings, an aluminum casting, a stainless-steel band and the necessary fasteners. A safety switch mechanism which prevents starting of the motor unless the locking handle is in place, is operated by a cam on the handle. The cam is made of nylon because of the wear resistance and insulating properties of this material.

Contemporary Design

Press Works on the Fly

SPEEDS as high as 900 strokes per minute are attained by a new stamping press in which the dies move in synchronism with the strip passing through the press. Speeds of 150 strokes per minute are seldom reached in the more conventional presses which require stopping of the material being fed during the actual press stroke. Although the idea of dies moving with the metal strip is not new, this is the first time a completely successful and vibrationless machine embodying the idea has been produced, according to the manufacturer, Wean Equipment Corp. An interesting sidelight is the fact that finished piece ejection actually becomes easier as press speed is increased because of increased strip velocity.

Fig. 1—Internal porosity in weld deposit made from improperly balanced alloy-steel electrode, as shown by radiograph



Selecting Electrodes and Welding Rods

Properties and characteristics of filler metals for welding

Part 1—Mild and Low-Alloy Steels

By Helmut Thielsch
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SELECTION of the proper filler metal for welding depends not only upon cost but also upon service conditions. In welding an SAE steel where only minimum strength and ductility are requirements, any of several types of alloy-steel electrode compositions falling within the corresponding AWS EXXXX tensile-strength classification may be sufficient. On the other hand, the chromium-molybdenum alloy-steel grades which are used in high-temperature pressure vessel and piping applications must be welded with electrodes of corresponding tensile strengths and compositions. Similar special considerations may hold true for alloy steels used at subzero temperatures or in corrosive service environments.

In welding with covered electrodes, the quality and properties of the weld deposit are influenced by the formulation of the electrode covering. An "off" formulation may result in cracking or serious porosity as illustrated in *Fig.* 1. Electrodes with low-hydrogen type coverings are often preferred for welding pressure vessels and pressure

Fig. 2 — Crack in carbon-steel weld deposit located between carbon-molybdenum steel base metal and carbon-molybdenum steel weld metal. Crack would have been avoided if the weld had been made with a carbon-molybdenum steel electrode

piping made of alloy steels. Other coverings are more widely used for welding carbon steels and certain alloy steels in noncritical applications and/or light gages where the relatively small degree of restraint permits welding without cracking. For fillet welds, electrodes with iron-powder type coverings are frequently specified since they can be used as contact electrodes with a "drag" technique.

The ever-widening field of application of carbon and alloy-steel welding is continually accompanied by extensive development of electrodes and welding rods. The American Welding Society and the American Society for Testing Materials, through jointly sponsored committees, have prepared and are preparing various specifications to cover the major electrode and welding-rod materials.

Table 1—Production of Steel Electrodes in 1954

AWS Classification	Production (million pounds)
E45XX	0.9
E6010	74.4
E6011	21.0
E6012	121.1
E6013	59.6
E6020, E6030	21.0
E6015, E6016, E7015, E7016	17.0
E70XX (except E7015, E7016)	11.1
E80XX E90XX, E100XX, E120XX (except EXX15 and EXX16)	0.4
E8015, E9015, E10015, E12015 and corresponding EXX16 types	6.7
Coiled steel wire	14.3

Data from National Electrical Manufacturers Assn.

Carbon and alloy-steel electrodes and welding rods should preferably be purchased to these specifications. Some of the so-called "special" or "all-purpose" electrodes, often marketed at a very much higher price and without any identification as to their composition, have occasionally led to considerable trouble and ultimate service failure.

Extreme care should be exercised in the selection of the proper electrode or welding rod materials. The designer should be aware of the composition of the welding materials specified by him. Every precaution should also be taken that the welder is actually supplied with the proper electrodes or welding rods.

A near failure in a repair weld made on a carbon-moly steel valve (approximately 0.16 C, 0.47 Mo) is shown in *Fig.* 2. The weld was made with a carbon-steel electrode prior to field welding with carbon-moly steel electrodes into a main steam piping system operating at 900 F and 900 psi in a power station. Although the dissimilarity in composition might have been considered negligible, the elevated temperature service caused diffusion of carbon atoms from the carbon-steel repair weld into the adjacent carbon-moly steel area. The resulting weakening allowed initiation and slow propagation of a crack in the carbon-steel repair weld. Had this cracking not been determined in time, a very disastrous failure might have resulted.

In addition to specifications prepared by the American Welding Society and the American Society for Testing Materials, specifications have also been prepared by various government establishments. These specifications may designate elec-

Table 2—Characteristics of Mild and Low-Alloy Steel Electrodes

AWS-ASTM Classification*	Current and Polarity	Welding Positions	Type of Covering	Penetration	Surface Appearance	Slag
EXX10	Dc, reverse polarity (electrode positive) only	All	High cellulose-sodium	Medium to deep	Flat, wavy	Thin
EXX11	Ac, or dc, reverse polarity (electrode positive)	All	High cellulose-potassium	Medium to deep	Flat, wavy	Thin
E6012	Dc, straight polarity (electrode negative) or ac	All	High titania-sodium	Medium	Convex, rippled	Heavy
EXX13	Ac or dc, straight polarity (electrode negative)	All	High titania-potassium	Shallow	Flat or concave, slight ripple	Medium
EXX15	Dc, reverse polarity (electrode positive) only	All	Low-hydrogen sodium	Medium	Flat, wavy	Heavy
EXX16	Ac or dc, reverse polarity (electrode positive)	All	Low-hydrogen potassium	Medium	Flat, wavy	Heavy
EXX20	Dc, straight polarity (electrode negative) or ac for H-fillets; dc, either polarity, or ac, for flat-position welding	H-fillets and flat	High iron oxide	Deep	Flat or concave, smooth	Heavy
EXX24	Dc, either polarity, or ac	H-fillets and flat	Iron-powder, titania	Low to medium	Smooth, fine ripple, slightly convex	Heavy
EXX27	Dc, straight polarity (electrode negative), or ac for H-fillets; dc, either polarity, or ac for flat-position welding	H-fillets and flat	Iron-powder, iron oxide	Medium	Smooth, fine ripple, flat or slightly concave	Heavy
EXX30	Dc, either polarity, or ac	Flat only	High iron oxide	Deep	Flat, smooth	Heavy

*The two digits XX in the electrode classification indicate the minimum tensile strength of the deposited weld metal. The last two digits represent the type of covering. Thus an E8010 electrode will produce a weld deposit with a tensile strength of over 80,000 psi (see *Table* 3) and will have a high-cellulose, sodium-type covering. For mild-steel electrodes, the tests are made in the as-welded condition, whereas for low-alloy steel electrodes the tests are made on stress-relieved specimens.

trode or welding-rod materials of particular core wire and, when applicable, covering compositions. Certification by the electrode manufacturer that his electrodes and welding rods meet a particular specification is usually sufficient. In most specifications, the weld deposits are required to meet certain physical and/or chemical requirements. Prior to acceptance of a lot of electrodes or welding rods, a special acceptance test may also have to be performed before welding of the structure itself may be commenced.

Before reviewing characteristics of the major electrode materials, the relative importance of the various classifications on the basis of their consumption should be considered, *Table* 1. Among the mild-steel electrodes, the E6012 classification is by far the most widely used with other E60XX types following in decreasing quantities. However, on alloy steels the low-hydrogen types (E8015, E8016, E9015, etc.) are by far more extensively used than the other types. Consumption of bare wires as used for the submerged-arc and inert-gas arc-welding processes represents about 5 per cent of the volume of covered electrodes.

Covered Mild and Low-Alloy Steel Electrodes: Primary purposes of the covering on shielded-metal arc-welding electrodes are (1) to prevent or minimize absorption of atmospheric oxygen and nitrogen by the molten weld metal by providing a gas shield against the atmosphere, (2) to facilitate weld-metal alloying and deoxidation, and (3) to stabilize the arc.

In the AWS-ASTM specifications[1,2] the covered electrodes generally are grouped according to (1) their operating characteristics, (2) the type of covering, and (3) the properties of the deposited metal. Operating characteristics and types of covering are described in detail. Weld-metal properties are specified only to the extent of mechanical properties. Requirements for chemical composition for low-alloy steels may also be specified. Suitable designations also are included in the specification for covered low-alloy steel electrodes.

In the classification numbering system adopted, the letter E which precedes the number denotes that the electrode is a metal-arc-welding electrode. The first two digits of the number following the letter E designate the minimum required tensile strength of a deposited all-weld-metal tensile-test specimen in thousand psi. The third and fourth digits designate the operating characteristics of the electrodes. The third digit, in particular, refers to the positions of welding in which the respective covering type can be used satisfactorily. Thus, the third digit may be 1, for all positions; 2, for horizontal and flat positions; or 3, for flat position only. Operating characteristics are summarized in *Table* 2 for the various standard electrode types. Minimum tensile strength and ductility requirements for all-weld-metal weld deposits are given in *Table* 3.

[1]References are tabulated at end of article.

Electrodes in the E60XX class, which are tested in the as-welded conditions, generally have mild-steel core wires. Alloying elements needed in the low-alloy steel electrodes to provide required weld properties are either added in the covering, or low-alloy steel core wires are used. Weldments made from low-alloy steel electrodes must be stress-relieved before being tested according to the AWS-ASTM specifications. With the exception of deposits from the so-called low-hydrogen electrode types, EXX15 and EXX16, the deposits will have a higher tensile strength and yield point, and a lower elongation and reduction of area, in the as-welded than in the stress-relieved condition.

Low-alloy steel electrodes may be used only to meet certain mechanical properties or to meet, in addition, particular chemical composition requirements. Where chemistry is also to be specified,

Table 3—Minimum AWS-ASTM Requirements for All-Weld-Metal Specimens

AWS-ASTM Classification	Tensile Strength (1000 psi)	Yield Strength (1000 psi)	Elongation in 2 in. (per cent)
E4510*	45	Not specified	5
E4520*	45	Not specified	5
E6010*	62	50	22
E6011*	62	50	22
E6012*	67	55	17
E6013*	67	55	17
E6015*	67	55	22
E6016*	67	55	22
E6020*	62	50	25
E6024*	67	55	17
E6027*	62	50	25
E6030*	62	52	25
E7010†	70	57	22
E7011†	70	57	22
E7013†§	70	57	18
E7015†	70	57	22
E7016†	70	57	22
E7020†	70	57	25
E8010†	80	67	19
E8011†	80	67	19
E8013†	80	67	16
E8015†	80	67	19
E8016†	80	67	19
E8020†§	80	67	22
E9010†	90	77	17
E9011†	90	77	17
E9013†	90	77	14
E9015†	90	77	17
E9016†	90	77	17
E9020†§	90	77	20
E10010†	100	87	16
E10011†	100	87	16
E10013†	100	87	13
E10015†	100	87	16
E10016†	100	87	16
E10020†§	100	87	18
E12015†	120	107	14
E12016†	120	107	14

*Tested in the as-welded condition.
†Tested in the stress-relieved condition. Test specimen to be heated in furnace at rate of 300 to 350 deg F per hr until 1150±25 F is attained, where it is held for 1 hr per in. of thickness. Furnace-cool at same rate down to 600 F and remove specimen.
§Not included in the final AWS-ASTM specification.

the composition of the weld metal of low-alloy steel electrodes is designated by the classifications, in *Table* 4, which follow the four digits of the AWS EXXXX number (e.g., the -B2 in E8016-B2).

This table also gives the applicable covering types for alloy-steel electrodes recognized in the AWS-ASTM specifications. For example, chromium-molybdenum alloy-steel electrodes are recognized only with EXX10, EXX11, EXX13, EXX15 and EXX16 type coverings. A complete electrode classification number on the basis of mechanical properties alone would be E7010 or E9016. A complete electrode classification number on the basis of chemical composition, as well as mechanical requirements, would be E7010-A1, or E9016-B3.

Alloy-steel electrodes depositing weld metal of the -AX and -BX composition with coverings other than those listed in *Table* 4 are also produced and, in time, may be recognized by the AWS-ASTM specification.

Other composition types of low-alloy steel electrodes may also deposit weld metal which meets the mechanical properties required by the AWS-ASTM specifications or provide even higher tensile-strength values. For example, E15016 high-tensile electrodes are being produced by several electrode manufacturers for SAE 4130, 4340 and similar steels used in the aircraft and other industries where high tensile-strength steels are employed. In the stress-relieved condition (1150 F for 1 hr, air cooled), weld deposits from E15016 electrodes exhibit tensile strengths between 150,000 and 160,000 psi. In the normalized condition (1650 F, 1 hr, air cooled), which represents a common postheat treatment for weldments of these alloys, the tensile strength will be 130,000 to 140,000 psi. Annealed or normalized and tempered weld deposits would exhibit tensile strengths between 110,000 and 120,000 psi and between 130,000 and 140,000 psi, respectively.

Similar high-tensile electrodes, usually marketed as E9016, E10016, E11016 and E12016 types, are available for alloy-steel applications where the weld metal must provide a response to heat treatment (such as normalizing and tempering) comparable to the base metal. A common application for these electrodes is repair welding of high-tensile, low-alloy steel castings discussed in an earlier article. These heat-treatable and other special electrodes should be specified only if their welding characteristics and compositions are understood to insure that they are satisfactory for the base materials involved and the service environment to which the weldment is exposed.

Table 4—Composition Specifications for AWS-ASTM Electrodes

Suffix*	Alloy Type	Composition	Used With Electrodes . . .
-A1	Carbon-molybdenum	0.40-0.65 Mo	EXX10, EXX11, EXX15, EXX16, EXX20
-B1	Chromium-molybdenum	0.40-0.65 Cr, 0.40-0.65 Mo	EXX10, EXX11, EXX13, EXX15, EXX16
-B2	Chromium-molybdenum	1.00-0.50 Cr, 0.40-0.65 Mo	EXX10, EXX11, EXX13, EXX15, EXX16
-B3	Chromium-molybdenum	2.00-2.50 Cr, 0.90-1.20 Mo	EXX10, EXX11, EXX13, EXX15, EXX16
-C1	Nickel	2.0-2.75 Ni	EXX15, EXX16
-C2	Nickel	3.0-3.75 Ni	EXX15, EXX16

*Follows the regular AWS-ASTM classification number, e.g., the B2 in E8016-B2.

Cellulose Type Electrodes EXX10 and EXX11: EXX10 electrodes are designed for all-position welding for direct current, reverse polarity. The electrode provides a medium-to-deep penetrating, forceful, spray-type arc and produces a readily removable, thin, friable slag. The electrode covering is high in cellulose, usually exceeding 30 per cent by weight. The balance is generally made up of titanium dioxide and various types of magnesium or aluminum silicates and metallic deoxidizers such as ferromanganese and sodium-silicate solids.

Electrodes of this classification are recommended for all-position work where the quality of the deposit is of greatest importance, particularly on multipass applications in the vertical and overhead positions, where quality requirements must be met.

EXX11 electrodes are designed to duplicate the usability characteristics and mechanical properties of the EXX10 electrodes but for ac use. Although the EXX11 electrodes may be used on direct current, reverse polarity, a sacrifice in usability characteristics will be noted when compared with the EXX10 electrodes. Penetration, arc action, slag, and fillet-weld appearance are very similar to those obtained with the EXX10 electrodes.

Coverings are also high in cellulose; however, instead of the sodium silicate used in the EXX10 covering, potassium silicate is generally used in the EXX11 covering.

Since cellulose readily forms hydrogen, the cellulosic coverings are primarily used on the low-tensile, mild-steel E6010 and E6011 electrodes for welding the ordinary unalloyed mild steels which are less susceptible to hydrogen embrittlement than the hardenable alloy steels. They are commonly used in ship building, in welding pressure vessels, storage tanks and pipes, and in construction of bridges and buildings by welding when mild steels are extensively used. They also are used to advantage on galvanized plates and on wrought iron.

Titania Type Electrodes EXX12 and EXX13: EXX12 electrodes are designed for all-position welding for direct current, straight polarity, and for alternating current. Since this classification is produced only on mild-steel electrodes, it is usually referred to by the particular designation E6012. This electrode is characterized by medium penetration, slight spatter, and a dense slag which

completely covers the deposit. The electrode usually operates with a stable (quiet) arc, although the fine globular weld-metal transfer combined with a relatively short arc results in a rapid cracking sound.

The covering contains titania, usually exceeding 35 per cent by weight, as well as siliceous material such as feldspar or clay, a small amount of cellulose, metallic deoxidizers such as ferromanganese, and liquid sodium silicate as a binder. Small amounts of calcium compounds are added by some manufacturers to produce satisfactory arc characteristics with direct current, straight polarity.

Whereas single-pass welds may be of radiographic quality, multiple-pass welds may fall far short. Thus, the titania-type electrodes are used largely for light sheet-metal work and for fast production work involving moderate penetration and poor fit-up. Moreover, although E6012 electrodes are suitable for welding in all positions, they are most commonly used in the flat position.

EXX13 electrodes are also designed for all-position welding with direct current, straight polarity, or with alternating current.

Coverings are very similar to those of E6012 electrodes. Because of the use of a potassium-silicate binder instead of the sodium-silicate binder used in the E6012 electrodes, the EXX13 electrodes are also known as high titania-potassium type. In addition, easily ionized materials are added to the covering to permit the establishment and maintenance of an arc with alternating current at low welding currents and low open-circuit voltages. For these reasons electrodes of small diameters (1/16, 5/64 and 3/32-inch) with this covering are primarily used on light sheet-metal work. Penetration is shallow, which is desirable in sheet welding since it minimizes distortion. The arc action tends to be quieter and the bead surface smoother and with a finer ripple than is obtained with E6012 electrodes.

The radiographic quality of welds made with EXX13 electrodes is usually good. Moreover, welds from the EXX13 electrodes are cleaner from the standpoint of slag and oxide inclusions than the welds from E6012 electrodes.

Low-Hydrogen Types EXX15 and EXX16: EXX15 electrodes are designed for all-position welding for direct current, reverse polarity.

The covering consists largely of minerals, of which a high percentage are gas-forming materials such as calcium, magnesium and sodium carbonates. The coverings are slightly thicker than those normal for each diameter of wire. The operation and arc characteristics of the low-hydrogen electrodes are similar to those of stainless-steel electrodes. A short arc must be maintained during welding in order to confine the arc atmosphere to the welding zone.

These coverings are essentially free from hydrogen because of the careful elimination of any hydrogen-bearing materials, other than water, from the covering and because of special baking procedures employed by the manufacturer which reduce moisture content to less than 0.2 per cent. During welding, the coverings provide a voluminous gas shield which is generated by the decomposition of the carbonate ingredients and which dilutes whatever residual moisture does enter the arc atmosphere.

Although little used in mild steel, properly alloyed electrodes in the low-hydrogen coverings are extensively used for welding the high-strength, high-carbon and ferritic alloy steels, *Fig.* 3, in which the ordinary coverings may produce what is known as "underbead cracking." These underbead cracks occur in the heat-affected zone in the base metal underneath the weld deposit. They are primarily associated with hydrogen, which is present in conventional EXX10, EXX11, EXX12 and EXX13 electrode coverings, and which increases the already existing internal stresses to values which produce cracking.

The reduction of hydrogen in these electrodes usually allows the welding of alloy steels at preheat temperatures somewhat lower than the tem-

Fig. 3—Shielded metal-arc welding of 1¼ Cr, ½ Mo piping with E8016-B2 electrodes. Joint area preheated to 500 F by induction heating

peratures recommended for the other electrode types. (Cracking, however, may also be minimized by preheat treatments at sufficiently high temperatures which allow hydrogen diffusion out of the weld area and produce certain beneficial structural changes.) The low-hydrogen electrodes are also used on malleable iron, on spring steels, for welding the mild-steel side of clad stainless-steel plates, for welding steels which subsequently are to be enameled, for welding all high-sulphur or selenium-bearing steels, for welding the proprietary low-alloy, high-strength steels and silicon steels.

EXX16 electrodes are also designated for all-position welding for alternating current or for direct current, reverse polarity, usually operating better on direct current, reverse polarity. Instead of the sodium silicate the EXX16 types contain potassium silicate. Because of a higher titanium oxide content, most commercial EXX16 electrodes have better operating characteristics than EXX15 electrodes. The weld deposits are less convex and slag is more readily removed from EXX16 electrode deposits than from EXX15 electrode deposits. Because of these advantages the EXX16 electrodes are more widely used than the EXX15 low-hydrogen type.

Iron-Oxide Types EXX20 and EXX30: EXX20 electrodes are designed for horizontal fillet and flat-position welding for alternating current or direct current, straight polarity.

The covering is essentially an all-mineral type with a high percentage of iron oxide, manganese compounds, and silica and with a sodium-silicate binder. Cellulose rarely exceeds 5 per cent, but since the volume of gas generated by the iron oxide coverings is far less than that of the other electrode types, these electrodes must not be considered to be low-hydrogen types. Weld deposits, particularly on air-hardening steels, may be subject to hydrogen embrittlement.

The electrodes are characterized by a spray type metal transfer, good stability, and a heavy slag, well honeycombed on the underside, which completely covers the deposit and can be readily removed. Moreover, they produce high-quality, deep-penetration weld deposits which meet rigid radiographic inspection. High deposition rates can be obtained on flat fillet and groove welds in heavy plates. This type of electrode is rarely used on thin sections because of increased warpage resulting from the higher currents usually employed. Applications include pressure vessels, heavy machinery bases, and many other types of structural parts.

EXX30 electrodes are designed for flat-position welding for direct current or alternating current. When direct current is used, best results are obtained with reverse polarity.

The covering, although similar to that used on EXX20 electrodes, is adjusted to reduce the fluidity of the slag, thus decreasing the possibility of slag interference in confined spaces.

These electrodes are recommended for welding heavy plates in the flat position. Their greatest volume of application is in the construction of pressure vessels where narrow, deep grooves are usually specified.

Iron-Powder Types EXX24 and EXX27: In recent years the major electrode manufacturers have marketed electrodes containing iron powder in the flux covering. The iron powder fuses along with the core wire and the balance of the covering ingredients.

Coverings are very heavy, usually amounting to 50% of the electrode weight. The electrodes are characterized by high-speed deposition which is somewhat offset by their higher manufacturing cost. The bead appearance generally is very good. Moreover, the slag is very easily removed.

The electrodes are extensively used as contact electrodes with a "drag" technique.

Fig. 4 — Automatic submerged-arc welding of carbon-steel piping with carbon-steel electrode (wire) and unalloyed flux

Unfortunately, advantages claimed for these electrodes have sometimes been exaggerated. Quality and properties of the weld deposits from most commercial iron-powder types produced presently are somewhat inferior to those of weld deposits from the E6015, E6016, E6010 and E6011 types. For these reasons, the iron-powder electrodes are most suited for applications in which E6012, EXX13 and some EXX20 and EXX30 electrodes are now being used, particularly as fillet welds. Further development may increase their range of application.

Welding Rods: Welding rods for carbon and low-alloy steels welded by gas welding, carbon arc welding, inert-gas carbon or tungsten arc welding and certain other arc-welding processes are covered by ASTM-AWS specification A251-46T.[3] According to AWS terminology, welding rods refer to "filler metal, in wire or rod form, used in gas welding and brazing processes, and those arc-welding processes wherein the electrode does not furnish the filler metal."

Six mild-steel classifications, based upon the tensile strength of all-weld-metal tensile specimens, are specified, *Table* 5. The G in the classification numbers represents gas welding. The letter A indicates relatively high ductility, whereas B refers to a lower ductility. The two numbers following the A or B represent the minimum stress-relieved tensile strength in thousand psi.

In addition to the mild-steel welding rods listed in *Table* 5. welding rods of high-carbon steel and various alloy-steel compositions are available. Although it is generally advisible to specify welding rods of the same composition as the base metal to be welded, this is not always possible. Depending upon the particular welding process used, some of the alloying elements in the welding rod may be lost in part during melting by the flame or arc. Where this is objectionable, it may be advisable to specify welding rods with higher percentages of the particular elements, or with other elements which are not as readily lost but which produce similar properties in the weld. In fact, in most cases where matching the mechanical properties of the base and weld metals is the primary consideration, any one of several alloys may suffice, as pointed out in the discussion of covered electrodes. Until suitable specifications are available, individual welding-rod manufacturers should be consulted.

Table 5—AWS-ASTM Tensile Requirements for Welding Rods*

Classification No.	Plate Thickness (inch)	Treatment of Welded Specimen†	Tensile Strength (1000 psi, min)	Elongation in 2 in. (%, min)
GA65	¾	SR	65	20
		NSR	72	17
GA60	¾	SR	60	25
		NSR	62	20
GA50	¾	SR	50	28
		NSR	52	23
GB65	¾	SR	65	18
		NSR	72	15
GB60	¾	SR	60	20
		NSR	62	15
GB45	¾	NSR	45	..

*Using $\frac{3}{16}$ or ¼-inch welding rods.

†SR and NSR signify stress-relieved and nonstress-relieved, respectively. Stress relieving when prescribed in these specifications is for the purpose of developing the fundamental properties of the weld metal unaltered by locked-up stress. Values obtained from stress-relieved welded specimens are about 5 per cent lower in tensile strength and 10 to 20 per cent higher in elongation than those of nonstress-relieved specimens. Stress relieving shall be within the range of 1150 ± 25 F for 1 hr per inch of thickness. Specimens shall be heated in a suitable furnace at the rate of 300 to 350 deg F per hr until a temperature of 1150 ± 25 F has been attained. After this temperature has been reached, it shall be maintained for 1 hr for each inch or fraction thereof of the maximum thickness of the section. The specimens shall be cooled at the same rate specified for heating and may be removed from the furnace when temperature of the plates has reached 300 F.

Electrodes for Submerged-Arc and Inert-Gas Consumable Metal Arc Welding: Carbon and many alloy-steel compositions are available as bare rods or wires on spooled reels for the submerged-arc, *Fig.* 4, and inert-gas consumable metal arc welding processes. The surface is frequently copper-coated lightly to improve contact and prevent rusting. Other types of surface treatments prior to spooling are also being used.

Although not yet covered by suitable AWS-ASTM specifications, wires of carbon and the major alloy-steel compositions are available to deposit weld metal of similar mild and alloy-steel compositions as deposited from the AWS-ASTM covered electrodes already discussed.

In submerged-arc welding of alloy steels, some or all of the alloying elements may be incorporated into the flux so that an alloy-steel weld deposit may be made with carbon-steel electrodes (wires). In many alloy-steel compositions this practice is completely acceptable and satisfactory. However, in a few alloy steel compositions the use of alloy-steel electrodes (wire) with "unalloyed" flux is definitely to be preferred.

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This article is the fourth in a co-ordinated group of articles by Helmut Thielsch on welding and weldments. Previous articles, and issues of MACHINE DESIGN in which they appeared, are:

Wrought Carbon and Alloy Steel: Weldability ..... May, 1955
Weldability of Stainless Steel ..... June, 1955
Weldability of Cast Steels ..... July, 1955

REFERENCES

1. *Mild Steel Arc-Welding Electrodes:* ASTM Specification A233-55T; AWS Specification A5.1-55T; ASME (Boiler Constr. and Pressure Vessel Code) Specification No. SA-233.
2. *High Tensile and Low-Alloy Steel Covered Arc-Welding Electrodes:* ASTM Specification A316-54T; AWS Specification A5.5-55T; ASME (Boiler Constr. and Pressure Vessel Code) Specification No. SA-316.
3. *Iron and Steel Gas-Welding Rods:* ASTM Specification A251-46T; AWS Specification A5.2-46T; ASME (Boiler Constr. and Pressure Vessel Code) Specification No. SA-251.

PRODUCTION
Modern Practices in Manufacture
AND
DESIGN

Geometric

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TOLERANCES make or break a design. In general, principles of dimensional toleranc-ing are relatively well understood and commonly practiced. But geometric tolerances—limits on alignment, concentricity, straightness, etc.—are often neglected because they either are overlooked or seem difficult to specify rationally. Or when they are considered, limits specified on drawings are frequently unrealistic in terms of both functional requirements and economical manufacture—and the consequences are often unhappy ones.

This problem has been explored in detail within certain divisions of the American Machine and Foundry Co. Research was conducted to evaluate the influence, both economic and mechanical, of geometric tolerances upon high-speed mechanisms and automatic machinery.

Out of this study evolved (1) a plan for the specification of geometric tolerances and (2) a series of tolerances for common geometric situations. The purposes of this two-fold program were as follows:

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1.1 Plan for specifying geometric tolerances

Limits are considered to be of two kinds: (1) standard quality, economically obtainable with normal production facilities and usual care; (2) special quality, obtainable usually only at added cost. The recommended geometric tolerances for these two quality grades are listed on succeeding pages.

At AMF, no indication is provided on the drawing if standard quality tolerances are satisfactory. Both design and shop personnel have charts on hand showing the standard limits.

Special-quality tolerances are shown on a drawing only if the closer limits are absolutely required. The system used to designate the tolerances is shown on the example drawing. The table interprets the notations on the drawing in relation to the data presented on the following pages.

Surface roughness ranges for processes in the various geometric situations are included in the tables, and are, in effect, summarized in the final section, 14.1. At times, surface roughness, rather than the geometric tolerance, may be the limiting criterion, and influence use of a special quality process when standard quality might otherwise be adequate.

The geometric tolerance is generally placed in a rectangle on the drawing. Placement of the rectangle, and the position and orientation of double lines of the rectangle, designate the detail limited by the tolerance. The double rules are placed on the lines or planes affected by the specification, or parallel to them, as shown by the examples. Circular and elliptical shapes are used when concentricity or "roundness" qualities are involved.

Interpretation of Example Drawing

Element	Dwg. Position	Reference	Interpretation
Alignment	M-7	2.1	Two plane surfaces at 180-deg angle
	L-7	2.2	Single hole system
	G-6	2.3	Two-keyway system
	D-13	2.4	In-line hole location
Angularity	J-5	3.1	Angle to datum plane
	J-10	3.2	Angle to hole
Concentricity	G-10	4.2	Total indicator reading
Flatness	I-11	5.1	Plane surface, dimensioned for specific area
Parallelism	O-7 C-22 L-2 K-20	6.1	Two plane surfaces, dimensioned
	M-20	6.1	Two plane surfaces, undimensioned
	F-16	6.2	Two-hole system
Perpendicularity	J-17	7.1	Single hole at 90-deg to plane
	J-8	7.2	Projection at 90-deg to plane
	M-13	7.3	Two holes centered on right-angle planes
Position	C-17	8.1	Define true position (TP) of untoleranced dimensions
Squareness	E-19 J-19	9.1	Two plane surfaces at 90 deg
	F-6	9.2	Ends, faces and shoulders at 90 deg to datum axis
	D-17	9.4	Two-hole systems at 90-deg in 180-deg plane
Straightness	I-17	10.1	Trueness of cylindrical surface
Symmetry	G-19	11.1	Position of median plane relative to datum axis
Out of roundness	I-7	12.1	Noncircular in cross section

Tolerances

. . . a plan for their simplified specification on drawings

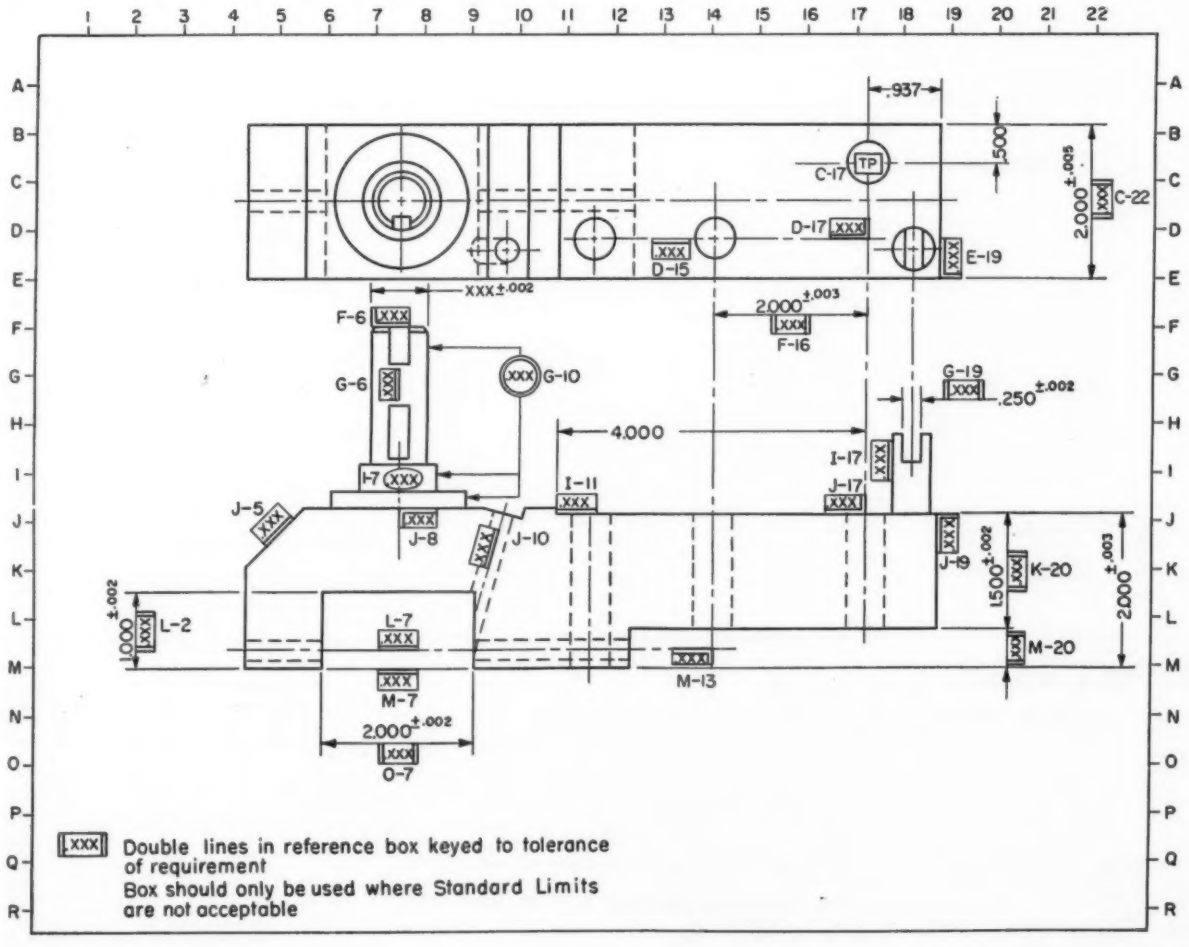
. . . a recommended schedule of standard and special-quality limits

1. To guide generation of the design in terms of economical shop practices; to develop criteria for inspection of the product against design intent.
2. To simplify tooling and reduce manufacturing costs by permitting the maximum tolerances that would not detract from performance of the product.
3. To permit refinement of drawings by eliminating or reducing explanatory notes; to contribute to simplified drafting practice.

Presented in outline form in this article are the details of the specification plan and the recommended tolerances for most situations.

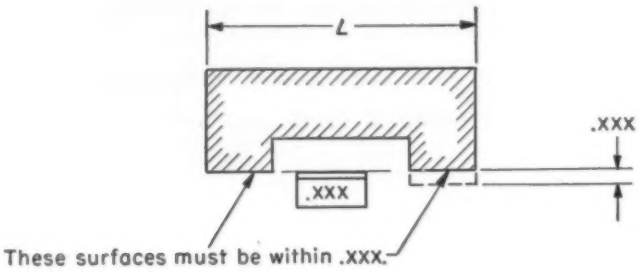
In general the quantity of parts or machines considered in this study ranged from one, through experimental quantities, to 10, 25 or 50 assemblies. Hence, certain of the conclusions may require modification before they can be applied in high-volume manufacture where special techniques and facilities may introduce different factors.

In all of the following tables, dimensional units are inches unless noted otherwise. Surface finish values are specified in microinches, arithmetical average (American Standard B46.1-1955).



2.1 Alignment—plane surfaces

Two plane surfaces in 180-deg plane

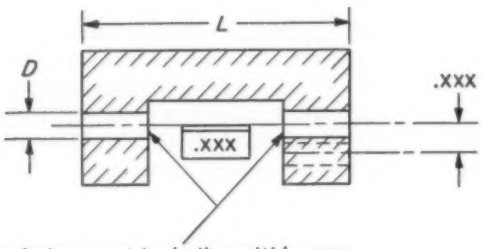


These surfaces must be within .XXX.

Quality	Standard*		Special**	
Process	Mill	Plane	Grind	Lap
Sur. Fin.	16-250	32-2000	63-250	0.1-16
L				
0 10 1.0	.0020		.0010	.0005
to 2.0	.0025		.0015	.0010
to 3.0	.0030		.0020	.0015
to 5.0	.0040		.0025	.0020
to 10.0	.0055		.0035	.0030
to 20.0	.0100		.0050	.0040

2.2 Alignment—hole system

Holes 180-deg in line

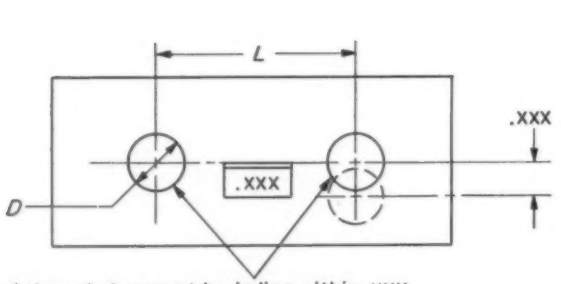


The ℄'s of these holes must be in line within .XXX.

Quality	Standard*		Special**		
Process	Drill	Ream	Jig Bore	Grind	Lap
Sur. Fin.	63-250	16-125	4-250	8-63	0.1-16
L	**D**				
0 to 1.0	0 to ⅛	.003	.0025	.0010	....	....
	to ¼	.0025	.0020	.0010	....	....
	to ½	.0020	.0015	.0010	.0003	.0002
	to ¾	.0020	.0015	.0005	.0003	.0002
	to 1.0	.0020	.0015	.0005	.0003	.0002
to 2.0	0 to ⅛	.0040	.0030	.0020	....	....
	to ¼	.0035	.0030	.0020	....	....
	to ½	.0035	.0025	.0015	.0005	.0003
	to ¾	.0030	.0025	.0015	.0005	.0003
	to 1.0	.0030	.0025	.0010	.0005	.0003
to 3.0	0 to ⅝	.0045	.0035	.0030	.0010	.0007
	to ¾	.0040	.0035	.0030	.0010	.0007
	to 1.0	.0040	.0035	.0030	.0010	.0007
to 5.0	0 to ½	.0060	.0040	.0035	.0020	.0015
	to 1.0	.0060	.0040	.0035	.0020	.0015
	to 1½	.0060	.0040	.0035	.0020	.0015

2.3 Alignment—hole locations

Holes in 180-deg plane

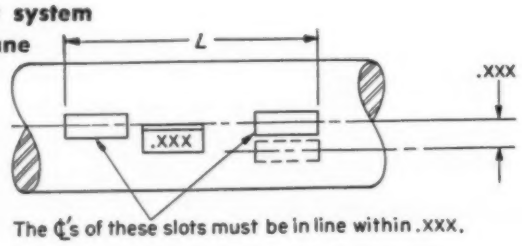


The ℄'s of these holes must be in line within .XXX.

Quality	Standard*	Special**
Process	Drill	Jig Bore
Sur. Fin.	62-250	4-250
L	**D**	
0 to 1.0	0 to ⅛	.0020	.0005
	to ¼	.0020	.0005
	to ½	.0020	.0005
	to ¾	.0020	.0005
	to 1.0	.0020	.0005
to 2.0	0 to ⅛	.0030	.0010
	to ¼	.0030	.0010
	to ½	.0030	.0010
	to ¾	.0045	.0010
	to 1.0	.0045	.0010
to 4.0	0 to ⅛	.0060	.0020
	to ¼	.0060	.0020
	to ½	.0060	.0020
	to 1.0	.0070	.0025
to 8.0	0 to ⅛	.0080	.0035
	to ¼	.0080	.0040
	to ½	.0080	.0040
	to 1.0	.0080	.0040

2.4 Alignment—keyway system

Slots in 180-deg plane



The ℄'s of these slots must be in line within .XXX.

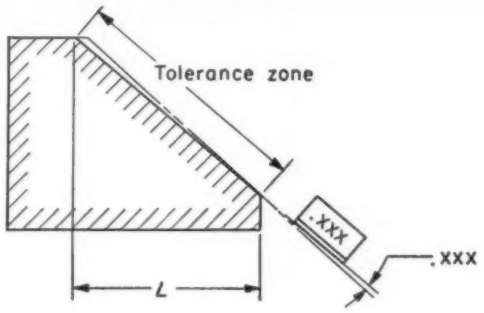
Quality	Standard
Process	Mill
Sur. Fin.	16-250
L	
1	.001
2	.0015
3	.002
5	.004
8-10	.005
10-18	.007

Special quality only by extra care.

*Not shown on drawing
**Shown with symbol on drawing

3.1 Angularity—plane surface

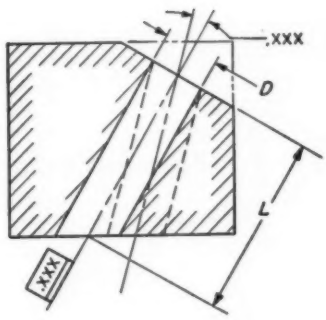
Angle to a reference plane



Quality	Standard*		Special**	
Process	Mill	Plane	Grind	Lap
Sur. Fin.	16-250	32-2000	8-63	0.1-16
L				
0 to 1.0	±2°	±2°	±1°	±45′
to 3.0	±1°	±1°	±30′	±20′
to 5.0	±30′	±30′	±15′	±10′
to 10.0	±15′	±15′	±10′	± 7

3.2 Angularity—hole location

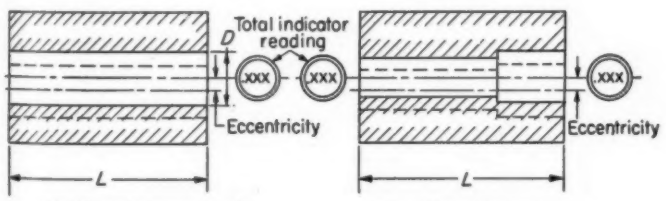
Angle to a reference plane



Quality		Standard*		Special**		
Process		Drill	Ream	Jig Bore	Grind	Lap
Sur. Fin.		63-250	16-125	4-250	8-63	0.1-32
L	D					
0 to 1.0	⅛ to 1.0	±2°	±1½°	±1¼°	±1⅛°	±1°
to 2.0	⅛ to 1.0	±1°	±50′	±45′	±35′	±20′
to 3.0	⅜ to 1.0	±30′	±25′	±20′	±15′	±10′
to 5.0	½ to 1½	±25′	±20′	±15′	±10′	± 8′

4.1 Concentricity—hole total runout

Holes made in same setup and in relation to each other and/or to OD



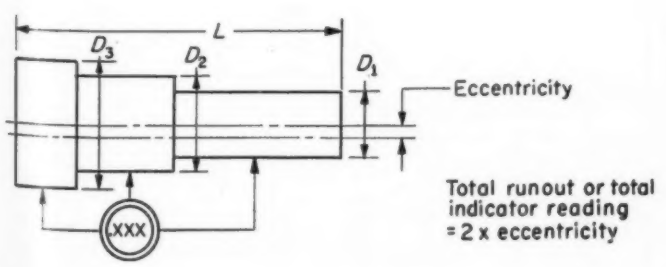
Hole in cold drawn stock (as chucked without any machining)

Two different holes in a turned piece

Quality		Standard*		Special**	
Process		Drill (Lathe) (Stock Size†)	Drill (Lathe) (Turned)	Bore	Grind
Sur. Fin.		8-63	4-250	16-1000	8-63
L	D				
0 to 1.0	⅛	.006	.0015	....	....
	to ¼	.006	.0015	....	....
	to ⅜	.006	.0020	....	....
	to ½	.006	.0020	....	....
	to ¾	.006	.0025	.0010	.0003
	to 1.0	.006	.0025	.0010	.0003
to 3.0	⅛	.008	.0030	....	....
	to ⅜	.008	.0030	....	....
	to ½	.008	.0030	....	....
	to ¾	.008	.0035	.0015	.0005
	to 1.0	.008	.0035	.0015	.0005
	to 1.5	.008	.0035	.0015	.0005
	to 2.0	.008	.0035	.0015	.0005
to 5.0	½	.010	.0050	.0020	.0015
	to 1.0	.010	.0050	.0020	.0015
	to 2.0	.010	.0060	.0020	.0015
	to 3.0	.010	.0060	.0020	.0015
to 10.0	1.0	.015	.0080	.0030	.0020
	to 3.0	.015	.0080	.0030	.0020
	to 5.0	.015	.0080	.0030	.0020

4.2 Concentricity—Surface total runout

Surfaces formed in same setup and in relation to each other and/or to OD



Quality		Standard*		Special**	
Process		Turn	Box Tool	Auto. Scr. Mach.	Grind
Sur. Fin.		4-250	16-250	16-250	8-63
L	D				
0 to 1.0	⅛	.001	.002	.002	.0005
	to ¼	.001	.002	.002	.0005
	to ½	.001	.002	.002	.0005
	to 1.0	.001	.003	...	.0005
to 2.0	¼	.0015	...	.003	.0008
	to ½	.0015	...	.003	.0008
	to 1.0	.0015	...	...	.0008
to 3.0	½	.0025	...	...	.0010
	to 1.0	.0025	...	...	.0010
to 5.0	¾	.0030	...	...	.0010
	to 1.5	.0030	...	...	.0015
	to 3.0	.0030	...	...	.0015

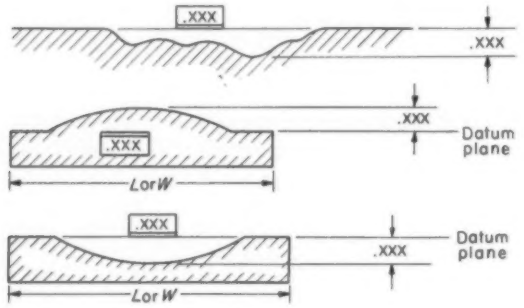
Where concentricity is specified without a tolerance a total indicator reading of .002-inch maximum is permissible.

Where no concentricity is specified, a total indicator reading of .003-inch maximum is permissible.

Gear blanks should be treated as special turnings and their tolerances determined specifically for the job.

5.1 Flatness—machined surfaces

Quality / Process / Sur. Fin.	Standard* Mill 16-250	Standard* Plane 32-2000	Special** Grind 8-63	Special** Lap 0.1-16
L by *W*				
1 by 1	.002		.0005	.0003
2 by 2	.002		.0005	.0003
3 by 3	.002		.0005	.0003
5 by 5	.003		.0005	.0004
10 by 6	.003		.0008	.0004
15 by 10	.0035		.0010	.0005
20 by 15	.005		.0015	.0006



5.2 Flatness—raw flat sheet

Stretcher-leveled stock

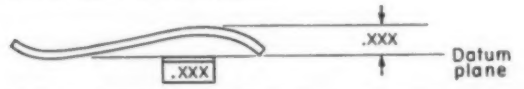
Quality / Sheet Size	Mill 0 to 12	Mill to 24	Mill to 48	Mill to 96
Thickness				
1/32 to 1/16	.040	.075	.105	.125
to 3/32	.030	.060	.090	.125
to 1/4	.025	.045	.060	.125

5.3 Flatness—sheet-metal parts

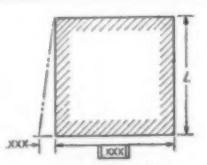
Stampings

Part Size	1/8 by 1	2 by 3	5 by 10	10 by 20	25 by 40
Thickness					
0 to 1/64	.010	.020	.035	.050	.060
to 3/64	.010	.020	.035	.040	.050
to 1/16	.008	.015	.025	.030	.040
to 3/32	.005	.010	.020	.025	.030
to 1/8	.005	.008	.020	.020	.025
to 1/4	.005	.008	.020	.020	.025

If closer tolerances are required, flattening and/or stamping at increased cost is necessary.



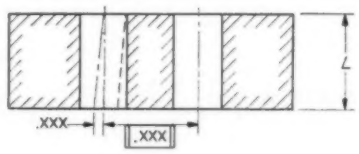
6.1 Parallelism—two plane surfaces



Quality / Process / Sur. Fin.	Standard* Mill 16-250	Standard* Plane 32-2000	Special** Grind 8-63	Special** Lap 0.1-16
L				
0 to 1.0	.001		.0005	.0002
to 2.0	.002		.0005	.0002
to 3.0	.0025		.0008	.0004
to 5.0	.004		.001	.0005
to 10.0	.005		.0015	.001
to 20.0	.007		.0025	.003

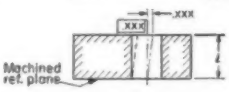
6.2 Parallelism—two holes

Quality / Process / Sur. Fin.	Standard* Drill 63-250	Standard* Bore 16-1000	Special** Jig Bore 4-250	Special** Grind 8-63
L	*D*			
0 to 1.0	1/8	.002	.0005	....
	to 1/4	.0015	.0005	....
	to 1/2	.0015	.001	.0005	.0003
	to 3/4	.0015	.001	.0005	.0003
	to 1.0	.0015	.001	.0005	.0003
to 2.0	1/8	.0035	.0008	....
	to 1/4	.003	.0008	....
	to 1/2	.003	.002	.0008	.0005
	to 3/4	.003	.002	.0008	.0005
	to 1.0	.003	.002	.0008	.0005
to 3.0	3/8	.0035	.0025	.001	....
	to 3/4	.003	.002	.001	.0006
	to 1.0	.003	.002	.001	.0006
to 5.0	1/2	.005	.003	.002	.0008
	to 1.0	.005	.003	.002	.0008
	to 1 1/2	.005	.003	.002	.0008



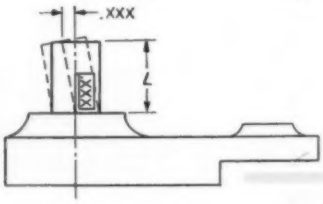
7.1 Perpendicularity—single hole

Quality / Process / Sur. Fin.	Standard* Drill 63-250	Special** Bore 16-1000	Special** Jig Bore 4-250
L	*D*		
0 to 1.0	1/8	.002	....	.0004
	to 1/4	.0015	....	.0004
	to 1/2	.0015	.0008	.0004
	to 3/4	.0015	.0008	.0004
	to 1.0	.0015	.0008	.0004
to 2.0	1/8	.0035	....	.0004
	to 1/4	.003	....	.0004
	to 1/2	.003	.0008	.0004
	to 3/4	.003	.0008	.0004
	to 1.0	.003	.001	.0005
to 3.0	1/4	.0035	.001	.0005
	to 1/2	.003	.001	.0005
	to 3/4	.003	.001	.0005
	to 1.0	.003	.001	.0005
to 5.0	1/2	.005	.002	.001
	to 1.0	.005	.002	.001
	to 2.0	.005	.002	.001
	to 2.5	.005	.002	.001



7.2 Perpendicularity—projection

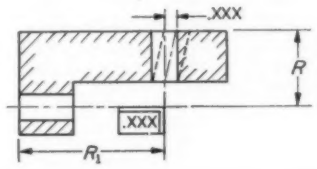
Quality / Process / Sur. Fin.	Standard* Turn 4-250	Standard* Hollow Mill 16-250	Special** Grind 8-63
L	*D*		
0 to 1.0	1/8	.0025	.001
	to 1/4	.0025	.001
	to 1/2	.0025	.001
	to 3/4	.0025	.001
	to 1.0	.0025	.001
to 2.0	1/8	.003	.0015
	to 1/4	.003	.0015
	to 1/2	.003	.0015
	to 3/4	.004	.0016
	to 1.0	.004	.002
to 3.0	1/2	.004	.002
	to 1.0	.005	.002
to 5.0	1.0	.006	.003
	to 2.5	.006	.003



*Not shown on drawing
**Shown with symbol on drawing

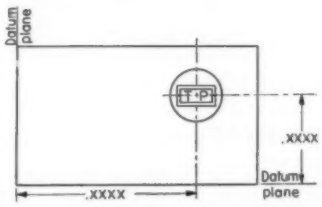
7.3 Perpendicularity—hole system

Quality	Standard*		Special**
Process	Drill	Bore	Jig Bore
Sur. Fin.	63-250	16-1000	4-250
$R_1 - R$			
0 to 1.0	.002	.001	.0005
to 2.0	.0025	.001	.0005
to 3.0	.003	.0015	.0005
to 5.0	.003	.0015	.0008
to 8.0	.005	.002	.001
to10.0	.007	.003	.002



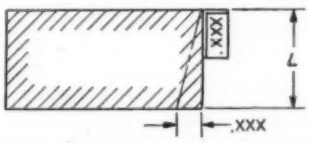
8.1 Position—

True position, untoleranced, for record or reference only



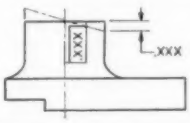
9.1 Squareness—plane surfaces

Quality	Standard*		Special**	
Process	Mill	Plane	Grind	Lap
Sur. Fin.	16-250	32-2000	8-63	0.1-16
L				
0 to 1.0	.001		.0005	.0002
to 2.0	.002		.0005	.0002
to 3.0	.0025		.0008	.0004
to 5.0	.004		.001	.0005
to 8.0	.005		.0015	.0005
to 10.0	.005		.0015	.001
to 15.0	.007		.0025	.003



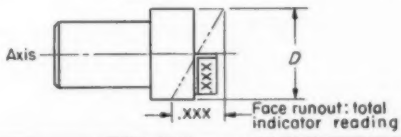
9.2 Squareness—ends, faces and shoulders

Quality	Standard*			Special**
Process	Spot	Mill	Plane	Grind
Sur. Fin.	125-250	32-2000	32-2000	8-63
Area (sq in.)				
0 to 1.0	.003	.002	.002	.001
to 2.0	.004	.0025	.0025	.001
to 3.0	.005	.003	.003	.0015
to 5.0	.007	.004	.004	.002
to 8.0	.008	.005	.005	.003



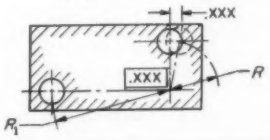
9.3 Squareness—turned faces

Quality	Standard*		Special**
Process	Face (Lathe)	Auto. Scr. Mach.	Grind
Sur. Fin.	32-500	16-250	8-63
D			
¼	.0020	.003	.001
to ½	.0020	.003	.001
to 1.0	.0030	.005	.002
to 2.0	.0035	...	.0025
to 3.0	.0040	...	.0025
to 5.0	.0050	...	.003
to 8.0	.0050	...	.003
to 10.0	.0100	...	.005

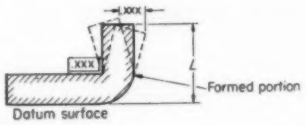


9.4 Squareness—hole system

Quality	Standard*		Special**
Process	Drill	Bore	Jig Bore
Sur. Fin.	63-250	16-1000	4-250
$R_1 - R$			
0 to 1.0	.002	.001	.0005
to 2.0	.0025	.001	.0005
to 3.0	.003	.0015	.0005
to 5.0	.003	.0015	.0008
to 8.0	.005	.002	.001
to 10.0	.007	.003	.002



9.5 Squareness—sheet-metal bends



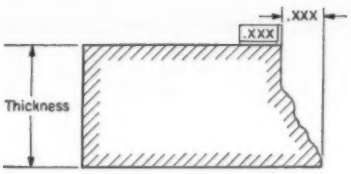
For ferrous and nonferrous stock not exceeding ½ hard temper

Quality	Standard* Form Tools—Brake						Special** Hand Form					
Process												
Thickness	0-.015	.035	.083	.125	.250	.500	0-.015	.035	.083	.125	.250	.500
L												
0 to 1.0	.015	.015	.015	.020	.020	.030	.010	.010	.010	.015	.015	.020
to 3.0	.020	.020	.020	.030	.030	.040	.015	.015	.015	.020	.020	.025
to 6.0	.030	.030	.040	.050	.060	.080	.020	.020	.025	.030	.035	.040
to 10.0	.050	.050	.060	.080	.080	.090	.030	.030	.030	.035	.040	.060
to 20.0	.065	.065	.080	.100	.100	.125	.040	.040	.060	.080	.080	.100

For ferrous and nonferrous spring stock, spring steel, phosphorous bronze, beryllium copper, hard brass, Dural, hard copper

Quality	Standard* Form Tools—Brake						Special** Hand Form					
Process												
Thickness	0-.015	.035	.083	.125	.250	.500	0-.015	.035	.083	.125	.250	.500
L												
0 to 1.0	.020	.020	.020	.025	.025	.035	.015	.015	.015	.020	.020	.025
to 3.0	.025	.025	.025	.035	.035	.045	.020	.020	.020	.025	.025	.030
to 6.0	.035	.035	.045	.055	.070	.090	.025	.025	.030	.035	.050	.070
to 10.0	.060	.060	.070	.090	.090	.100	.040	.040	.045	.070	.070	.085
to 20.0	.080	.080	.100	.115	.115	.150	.060	.060	.075	.090	.090	.115

9.6 Squareness—metal edges



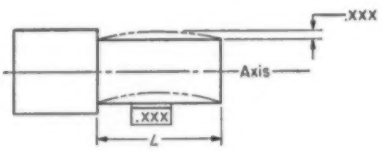
Quality / Process / Sur. Fin. / Thickness	Standard* Shear—Punch 0-.015	.035	.083	.125	.250	.500	Special** Saw 500-2000 0-.015	.035	.083	.125	.250	.500
Length												
0 to 5	.003	.004	.006	.010	.015	.025	.002	.003	.005	.008	.012	.015
to 10	.003	.006	.008	.012	.020	.030	.002	.004	.006	.010	.015	.025
to 30	.004	.008	.010	.015	.020	.030	.003	.005	.008	.012	.015	.025
to 72	.004	.008	.010	.015	.025	.035	.003	.006	.009	.013	.018	.030
to 96	.004	.008	.010	.020	.030	.050	.003	.006	.009	.015	.025	.035

Quality / Process / Sur. Fin. / Thickness	Special** Machine 16-250 0-.015	.035	.083	.125	.250	.500	Grind 8-63 0-.015	.035	.083	.125	.250	.500
Length												
0 to 5	.001	.001	.001	.002	.002	.003	.0005	.0005	.0005	.0005	.0005	.0005
to 10	.001	.001	.002	.002	.003	.004	.0008	.0008	.0008	.0008	.0008	.0008
to 30	.002	.002	.002	.002	.004	.005	.001	.001	.001	.001	.0015	.0015
to 72	.003	.003	.003	.003	.006	.008	.0015	.0015	.002	.002	.002	.0025
to 96	.005	.005	.005	.005	.010	.015	.002	.002	.003	.003	.005	.005

Soft materials in greater thicknesses should be sawed or machined for suitable square edges.

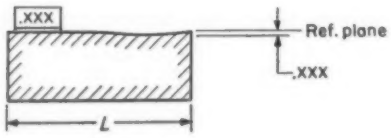
10.1 Straightness—cylindrical surface

Process / Sur. Fin. / Quality	Turn 4-250	Box Tool 16-250	Auto. Scr. Mach. 16-250	Grind 8-63
		Standard*		Special**
L	*D*			
0 to 1.0	⅛	.0015		.001
	to ¼	.0015		.001
	to ½	.0015		.001
	to 1.0	.0015		.001
to 2.0	¼	.002		.0015
	to ½	.002		.0015
	to 1.0	.002		.0015
to 3.0	½	.0025		.002
	to 1.0	.0025		.002
to 5.0	¾	.003		.002
	to 1½	.003		.002
	to 3.0	.003		.002



10.2 Straightness—plane surface

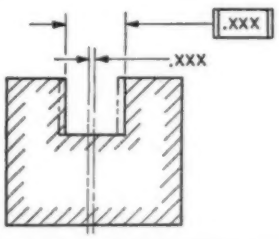
Quality / Process / Sur. Fin.	Standard* Mill 16-250	Plane 32-2000	Special** Grind 8-63	Lap 0.1-16
L				
0 to 1.0	.002		.0004	.0002
to 2.0	.002		.0004	.0002
to 3.0	.0025		.0005	.0003
to 5.0	.003		.0005	.0003
to 8.0	.0035		.0006	.0004
to 10.0	.004		.0008	.0005
to 15.0	.008		.0010	.0006



*Not shown on drawing
**Shown with symbol on drawing

11.1 Symmetry—rectangular aperture

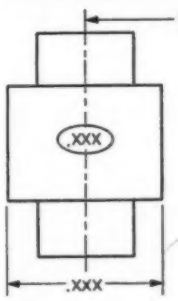
Quality / Process / Sur. Fin.	Standard* Mill 16-250	Special** Grind 8-63
Width		
0 to 1/16	.003	.001
to ¼	.003	.001
to ½	.003	.001
to 1.0	.005	.002
to 2.0	.005	.002
to 3.0	.006	.003
to 5.0	.006	.003



12.1 Out of Round—shaft turning

Quality / Process / Sur. Fin.	Standard* Turn 4-250	Special** Grind 8-63
Diam. Tol.		
± .0005	.0002	.0001
± .0010	.0004	.0002
± .0020	.0006	.0003
± .0050	.0008	.0004
± .0100	.0010	.0005

Total out-of-roundness tolerance should be less than dimension tolerance.



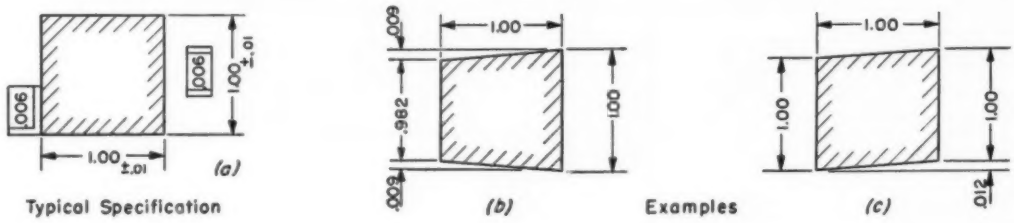
13.1 Geometric Combinations— parallelism and squareness

Where more than one geometric tolerance is applied to the same part, each requirement should be checked separately. It is possible that the part may adhere to one tolerance but violate another.

For example,

At *b*, the squareness tolerance is satisfied but the part is 0.018-inch out of parallel; the tolerance is 0.006-inch.

At *c*, opposing surfaces are parallel but the squareness tolerance is violated.



14.1 Surface Roughness—

Left of heavy line: practical finishes at commercial costs
Right of heavy line: obtainable finishes at increased costs

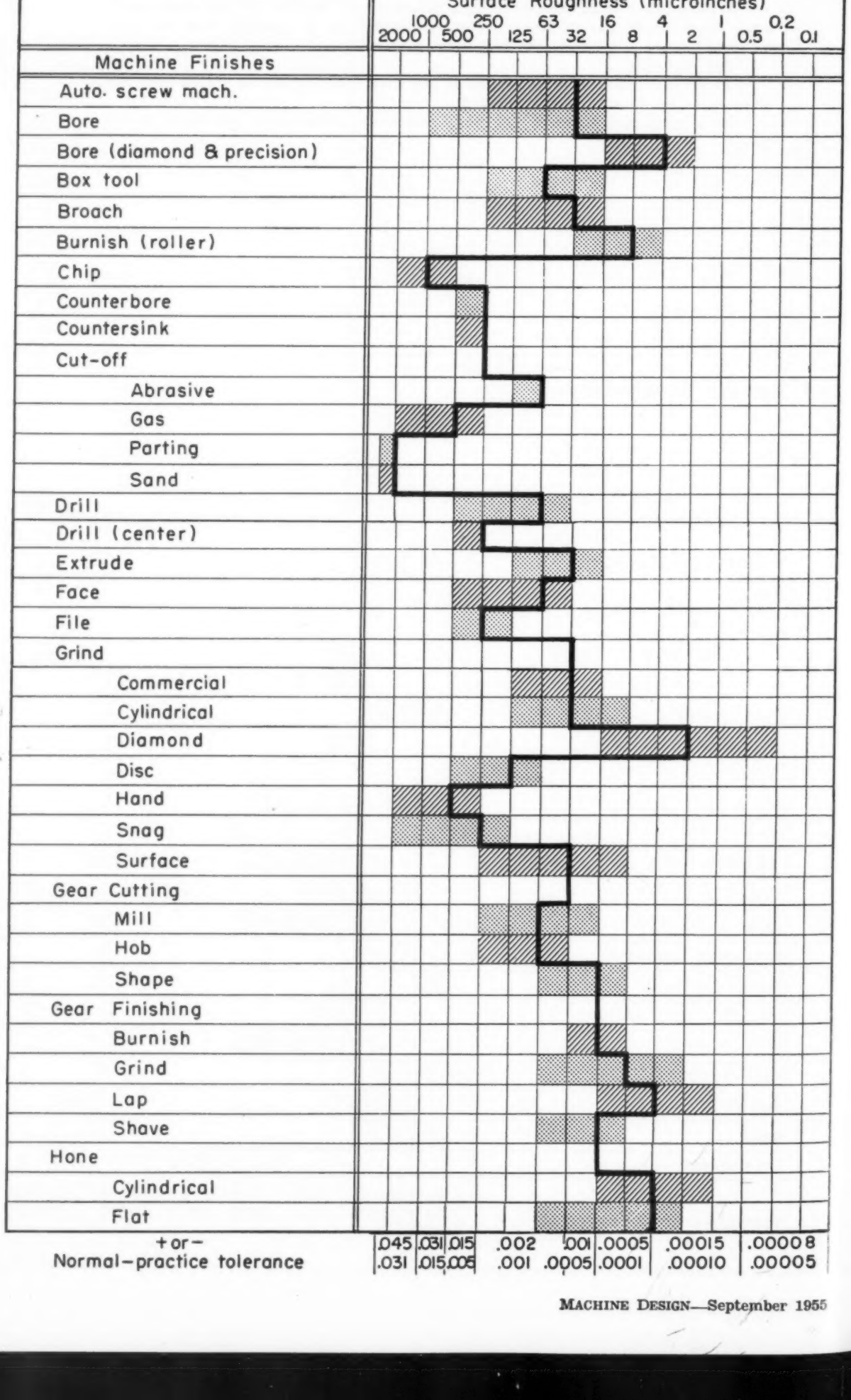
Natural Surfaces	Surface Roughness (microinches) 2000 | 1000 | 500 | 250 | 125 | 63 | 32 | 16 | 8 | 4 | 2 | 1 | 0.5 | 0.2 | 0.1
Cast	
Die	
Permanent mold	
Precision	
Sand	
Shell mold	
Coin	
Cold press (upset)	
Draw (cold)	
Extrude	
Forge	
Hone (liquid)	
Hot press (upset)	
Peen (shot)	
Powder metallurgy	
Roll (cold)	
Roll (hot)	
Swage	
Weld	
Thread roll	

+or−	.045	.031	.015	.002	.001	.0005	.00015	.00008		
Normal-practice tolerance	.031	.015	.005	.001	.0005	.0001	.00010	.00005		

Surface Roughness

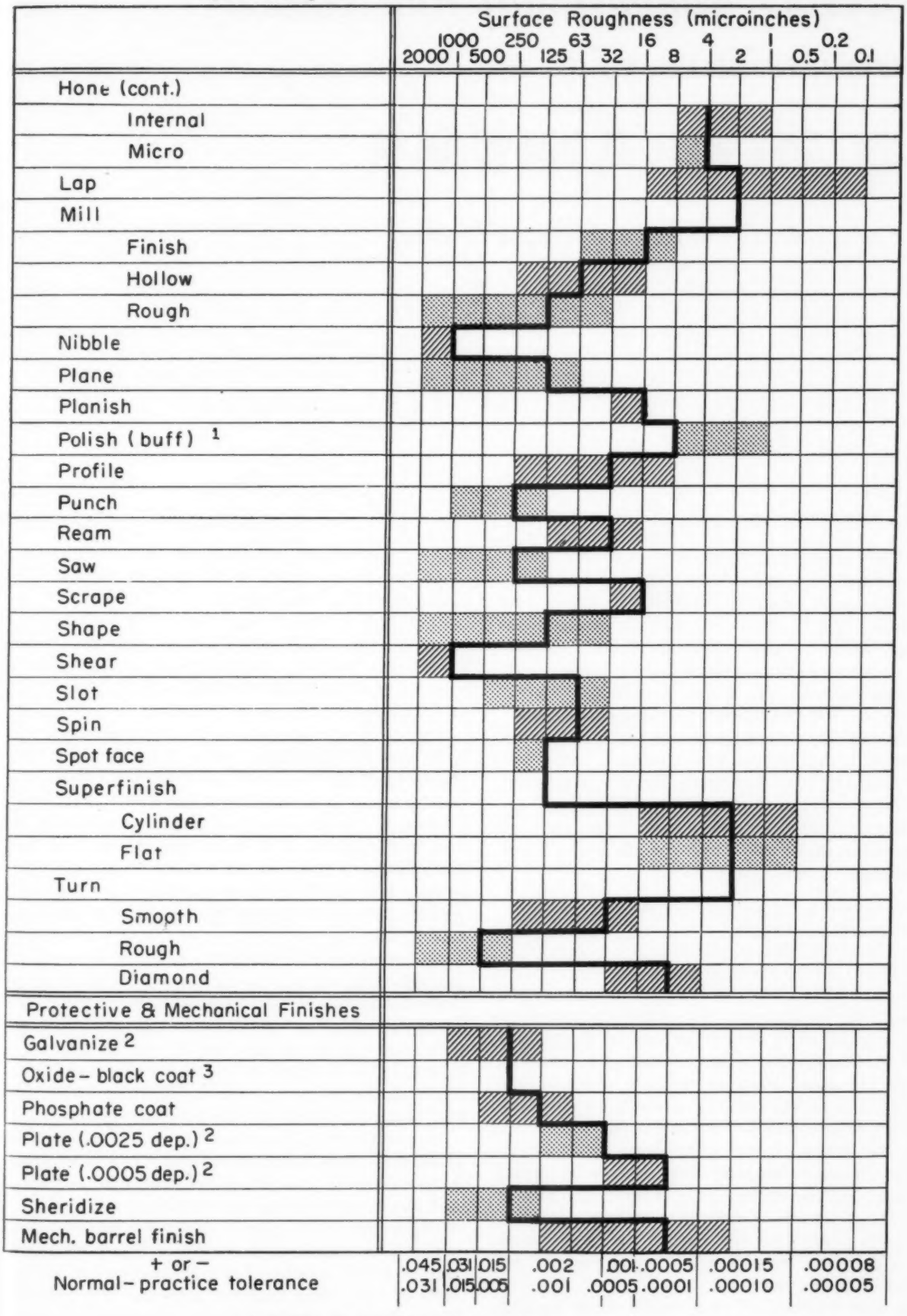
Left of heavy line: practical finishes at commercial costs

Right of heavy line: obtainable finishes at increased costs



Surface Roughness

Left of heavy line: practical finishes at commercial costs
Right of heavy line: obtainable finishes at increased costs



[1] Dependent on previous finish, grit and grade of abrasive
[2] Roughness increases with thickness of deposit
[3] Surface on which applied does not change

Analyzing dimensional and velocity characteristics of

3-D MECHANISMS

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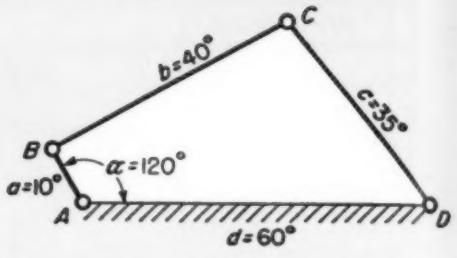


Fig. 1—Typical conic linkage in which the dimensions of the four sides and the instantaneous value of one corner angle are known

BASIC types and characteristics of "conic quadric" linkages have been discussed in a previous article.[1] Designed to connect two nonparallel shafts with intersecting axes, these four-bar linkages employ simple cylindrical pin joints and can be readily modified to duplicate, in three-dimensional form, the motion characteristics of many of the well-known conventional "plane" mechanisms. Typical mechanisms for which conic counterparts can be developed include the crank and rocker, the drag-link chain, Whitworth's quick-return mechanism and the slider-crank.

In this article, attention will be focused on two fundamental problems that arise in the use or development of conic linkages:

1. Configuration of a specific linkage in various successive positions.
2. Angular velocities of the linkage members for a given velocity of one link.

Graphical Techniques: The configuration of a given conic quadric mechanism can be determined either graphically or by trigonometric calculation, just as for plane four-bar linkages. In this discussion, the special problems encountered in graphical construction will be considered first.

An important basic characteristic of conic quadric chains is that all links can be described as lines upon the surface of a sphere. The size of this "base" sphere is relatively unimportant, except with regard to the overall space occupied. The scale factor has no effect upon angular velocities or displacements.

The four members of every conic chain are arcs of great circles on the base sphere and, therefore, will always appear as ellipses in a two-dimensional view. All of these ellipses must have major axes of the same length, which, in turn, is equal to the diameter of the base sphere.

Each link is measured by the angle that it subtends at the center of the base sphere. These angles give the four dimensions or "sides." Thus, a conic quadric chain involves eight angles: four sides, expressed as angles, plus four corner angles.

The design problem usually encountered is to draw a conic mechanism when the four sides and the corner angle between the driving member and the frame or fixed member are specified. For illustration, a specific example will be considered in which the sides a, b, c and d are known, and the instantaneous value of the corner angle α is assumed, *Fig.* 1. The objective is to locate point C which can be established by finding the intersection of two ellipses.

In problems of this type, it does not appear possible to avoid the use of ellipses; however, any desired ellipse can be produced quite rapidly and accurately by the well-known trammel method. This drawing technique, which will be discussed briefly later, is definitely preferred over any of the approximate methods, such as the four-arc method, commonly used in isometric projection.

CONSTRUCTION EXAMPLE: A typical conic quadric chain is depicted schematically in *Fig.* 1. Graphical construction of this linkage is illustrated in *Fig.* 2 and is accomplished by the following method.

First, the base sphere is drawn to any convenient size as shown in View 1 of *Fig.* 2. The fixed side or frame member AD is located on the "equator" in this view and will appear as a straight line. Point A, the driving crank center, is established on the surface of the sphere at the center of the circle representing the base sphere. Crank AB, therefore, must also always appear as a

[1]References are tabulated at end of article.

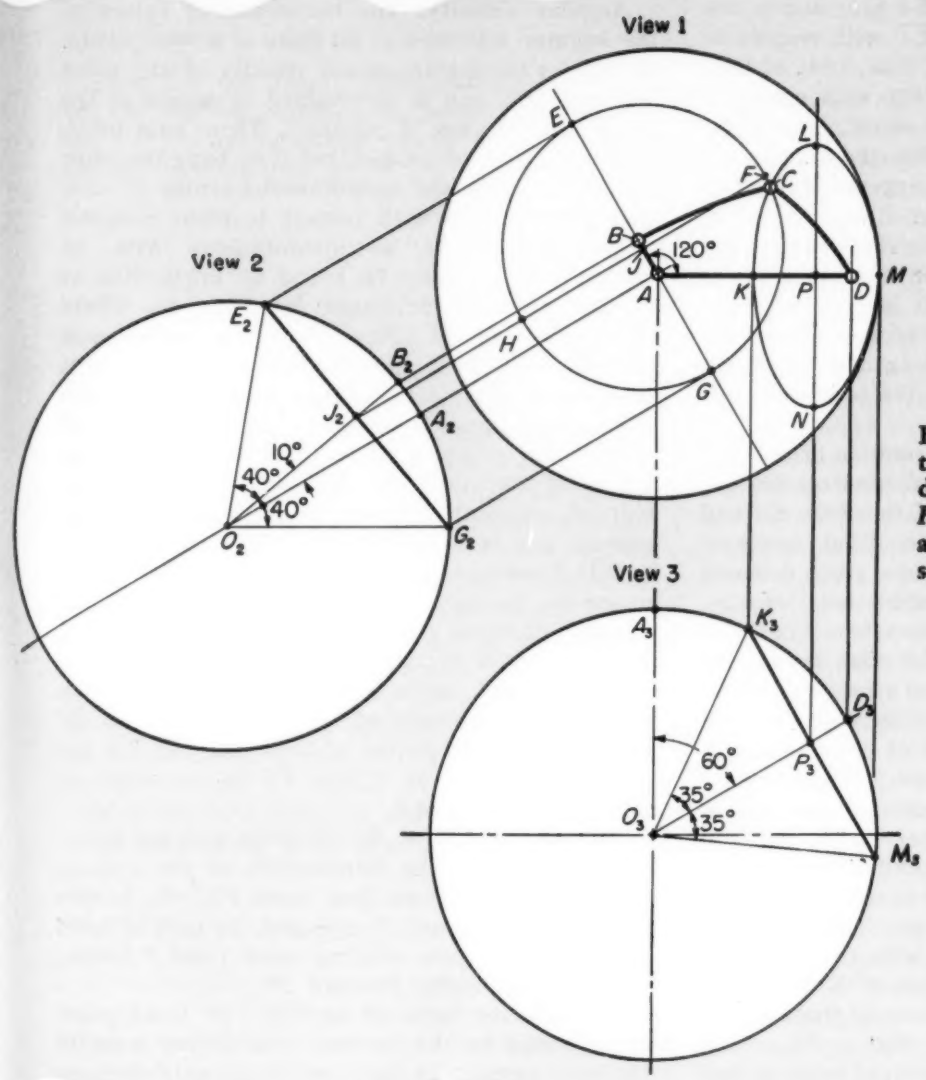


Fig. 2—Graphical construction of the conic linkage depicted schematically in *Fig.* 1 showing the use of auxiliary views and intersecting ellipses to determine the position of point *C*

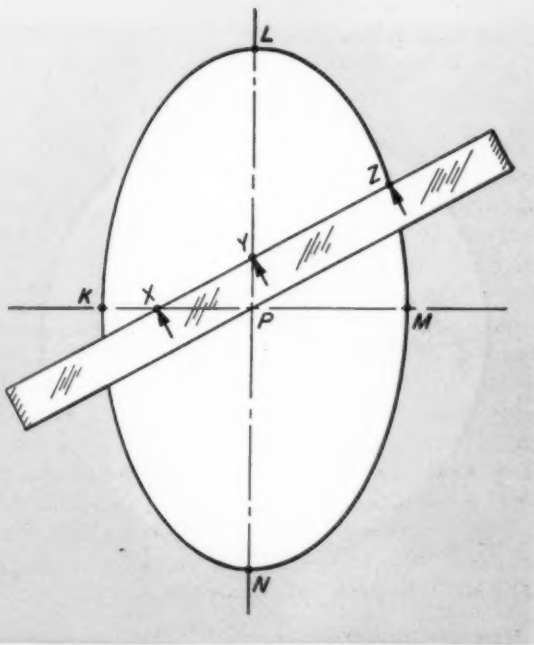
straight line in this view. The angle α, which is 120 degrees in this case, may thus be measured directly and the great circle corresponding to link *AB* drawn.

Point *B* is found by means of View 2 which is a normal projection of the great circle of link *AB*. In this view, points *A* and *B* appear as points A_2 and B_2 on the circumference of the projected circle and the central angle of 10 degrees, which is the measure of link *AB*, appears in true size. From this angular relationship, the position of point B_2 is determined and projected back into View 1.

Point *D* is found in a similar manner from a normal projection of the equator circle in View 3. The measured angle in this case is 60 degrees which is the dimension of link *AD*. From this view, the position of point D_3 is determined and projected to View 1.

For point *C*, a different approach must be used, based on the angular distances from both points *B* and *D*. In View 2 of *Fig.* 2, the line E_2G_2 is an edge view of a circle which is the locus of all points 40 degrees from *B*. This circle is thus a parallel

Fig. 3—Trammel method of ellipse generation



of latitude with respect to B as a pole and is the locus of all possible positions of C with respect to B. In View 1, the projection of this circle of latitude appears as the ellipse $EFGH$ with center J. Line EG, the minor axis of the ellipse, is the projected length of line E_2G_2; line FH, the major axis, is the true length of E_2G_2 as it appears in View 2.

The ellipse $KLMN$ with center P is obtained in a similar fashion. In View 3, line K_3M_3 is the edge view of a circle on which point C, as well as all points 35 degrees from D, must be located. Projected into View 1, this circle becomes the ellipse $KLMN$; line KM, the projected length of line K_3M_3, is the minor axis and line LN, the true length of K_3M_3, is the major axis.

Point C is located at the intersection of the two ellipses, completing the graphical construction unless the true elliptical shapes of the links BC and CD are required. The latter condition, however, is hardly worthwhile in most cases since it would involve drawing at least four additional views.

One short cut deserves consideration. The three views in *Fig.* 2 are basically the same because of the spherical nature of the construction. Thus, all three can easily be combined in a single view. This method has the advantage of increased accuracy since the projection lines are much shorter.

ELLIPSE DRAWINGS: The trammel method of drawing ellipses whose axes are known is illustrated in *Fig.* 3. The two perpendicular axes LN and KM are drawn through the center P and some convenient form of straight edge, even the edge of a sheet of paper, is marked with the two semi-axis dimensions to show the points X, Y and Z. The position of these three points is given by the following linear relationships: $XZ = PL = PN$ and $YZ = PK = PM$. The straight edge is then revolved in such a manner that point X is always on axis KM and point Y is maintained on LN. As the straight edge turns, point Z will trace the desired ellipse.

Angular Velocity: The instantaneous values of the angular velocities of all links of a conic chain, as well as the instantaneous velocity of any point within a link, can be determined by means of the instantaneous axes of rotation. These axes must, of course, first be located, but they have the same significance that the instantaneous center of rotation (centro) has with respect to plane motions.

The location of an instantaneous axis, or "axode," may readily be found by application of another theorem developed by Kennedy, whose classic theorem of three centros is well known and established in fundamental kinematics. His theorem of three instantaneous axes or, as he calls them, virtual axes is stated[2]: "The virtual axis of either pair of opposite links is the join of the planes of the other two: the virtual axis for any pair of adjacent links is the join of their own planes, and is a permanent axis."

This theorem is almost the same, and is applied in exactly the same manner, as the corresponding theorem of three centros. Thus, in *Fig.* 4*a* where O is the center of the base sphere, line AO is the fixed axis and axode of the links AB and AD, line BO is the axode of link AB relative to BC and, if the great circles of links AB and CD are extended to meet at P, line PO is the axode of link BC relative to AD.

The significance of the axode is perhaps better demonstrated by the introduction of the concept of the equivalent bevel gear train, *Fig.* 4*b*. In this case, points A, D and P represent the axes of bevel gears with the gear rotating about point P having two different radii, PB and PC.

The velocity ratio of any pair of bevel gears is expressed as the inverse ratio of the sines of the cone angles. In the case of the pair of gears with centers A and P, *Fig.* 4*b*, a cross sectional view taken through the plane of their axes will appear as shown in *Fig.* 5. The velocity ratio of gear A to gear P is

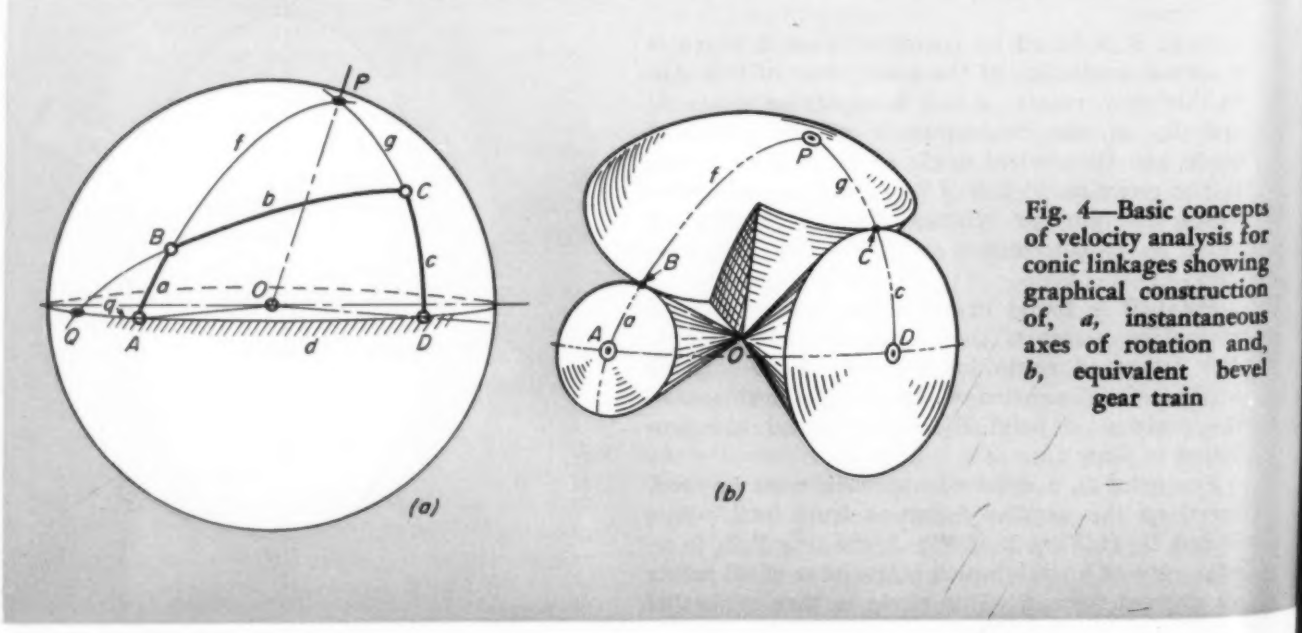


Fig. 4—Basic concepts of velocity analysis for conic linkages showing graphical construction of, *a*, instantaneous axes of rotation and, *b*, equivalent bevel gear train

$$\frac{\omega_A}{\omega_P} = \frac{\sin f}{\sin a} \quad \ldots\ldots (1)$$

Thus, for the quadric chain mechanism of *Fig. 4a*, the angular velocities of the two members *BC* and *CD* are related to the angular velocity of member *AB* (driving link) by

$$\omega_{BC} = \omega_{AB}\left(\frac{\sin a}{\sin f}\right) \quad \ldots\ldots (2)$$

$$\omega_{CD} = \omega_{AB}\left(\frac{\sin a}{\sin f}\right)\left(\frac{\sin g}{\sin c}\right) \quad \ldots\ldots (3)$$

where a, c, f and g represent the measure of the corresponding links, *Fig. 4a*, in degrees. For the angular velocities of members *AB* and *CD*, there is also an alternative expression that can be used in place of Equation 3. From the theory of instantaneous axes of rotation, the line *QO*, *Fig. 4a*, which is the axode of links *AB* and *CD*, must be located at the intersection or join of the planes containing members *BC* and *AD* of the linkage. This axode, *QO*, can be regarded as the line of contact along the pitch cones of two hypothetical bevel gears; a pinion *A* turning about axis *AO* and an internal-tooth gear *C* turning about axis *DO*, *Fig. 6*.

From this hypothetical arrangement, the angular velocities of a and c are given by

$$\omega_{CD} = \omega_{AB}\left[\frac{\sin q}{\sin (q+d)}\right] \quad \ldots\ldots (4)$$

This equation is the alternate expression for Equation 3 and will give the same solution. It offers a more direct method of finding ω_{CD} from ω_{AB}, when ω_{BC} is of no interest.

Analytical Method: Because of the uncertainties involved in the graphical method, it is probably better, from the standpoint of accuracy, to rely on analytical techniques. This approach involves calculation of the unknown "sides" and angles of three spherical triangles, using the methods of spherical trigonometry.

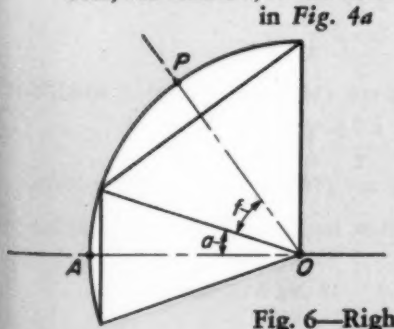
In conjunction with this method of analysis, it will be helpful to use certain concepts that have been developed for the solution of problems in navigation. The haversine, which is defined as $\sin^2 \theta/2$, is of great value because it eliminates ambiguity as to quadrant. This property of identification stems from the fact that the values of the haversines run from 0 to 180 degrees instead of from 0 to 90 degrees only. Tables of natural haversines and their logarithms can be found in several references[3].

As an example of the method of analysis, the quadric conic chain discussed previously, *Fig. 1*, will be considered. The problem is to find the angular velocity ratio between the driven arm *CD* and the crank *AB* when the crank velocity ω_{AB} is known. In view of the considerations discussed earlier, Equation 4 rather than Equation 3 will be used in the analysis. As a result, the problem will consist chiefly of finding the angle q which is subtended at the center of the sphere by the side *AQ*.

For purposes of this analysis, the sketch of the linkage shown in *Fig. 7* will be helpful. This sketch is similar to the one shown in *Fig. 2*, with point *A* directly over the center of the sphere. The great circles of links *AB* and *AD* then appear as straight lines. Sizes and shapes of the other two links are drawn only approximately. Although this drawing is merely intended to serve as a guide for calculations, reasonable care in making the sketch will frequently simplify identification of the quadrant of various angles in the analysis.

The next step is to sketch in the great circle

Fig. 5 — Below — Cross-section of mating bevel gears with equivalent relative velocity characteristics of the two connecting members, *AB* and *BC*, in the conic linkage shown in *Fig. 4a*



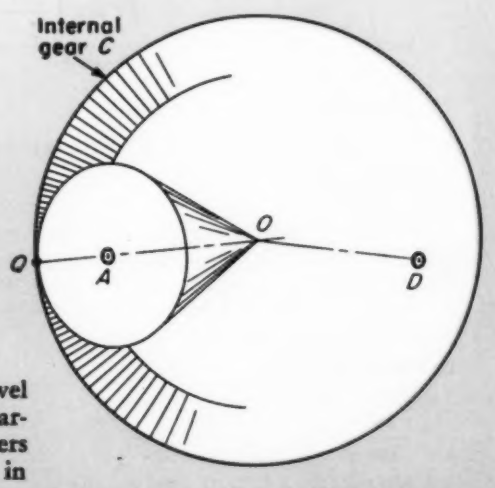


Fig. 6—Right—Construction of mating bevel gears with equivalent relative velocity characteristics of the two opposite members *AB* and *CD*, in the conic linkage shown in *Fig. 4a*

Sample Calculations

General linkage arrangement and symbol notations are shown in *Fig. 7*. The term haversine has been shortened to its abbreviated form "hav" for convenience.

Triangle *ABD*

Design Data:

$a = 10$ deg
$d = 60$ deg
$\alpha = 120$ deg

Calculations:

1. Side m

Basic equation:

$$\text{hav } m = \text{hav } (d - a) + \sin d \ (\sin a) \ (\text{hav } \alpha)$$

$\log \sin d = \log \sin (60 \text{ deg}) = 9.93753\text{-}10$
$\log \sin a = \log \sin (10 \text{ deg}) = 9.23967\text{-}10$
$\log \text{hav } \alpha = \log \text{hav } (120 \text{ deg}) = 9.87506\text{-}10$
By summation, $\log \text{hav} = 9.05226\text{-}10$
For this log value, hav $= 0.11278$
hav $(d - a) =$ hav $(50 \text{ deg}) = 0.17861$
hav $m = 0.29139$

$m = 65$ deg 20.5 min

2. Corner angle β

Basic equation:

$$\frac{\sin m}{\sin \alpha} = \frac{\sin d}{\sin \beta}$$

$$\sin \beta = \sin d \ (\sin \alpha) \ (\csc m)$$

$\log \sin d = \log \sin (60 \text{ deg}) = 9.93753\text{-}10$
$\log \sin \alpha = \log \sin (120 \text{ deg}) = 9.93753\text{-}10$
$\log \csc m =$
$\log \csc (65 \text{ deg } 20.5 \text{ min}) = 0.04153$
By summation, $\log \sin \beta = 9.91659\text{-}10$

$\beta = 55$ deg 36.9 min

Triangle *BCD*

Design Data:

$m = 65$ deg 20.5 min.
$b = 40$ deg
$c = 35$ deg

Calculations:

1. Corner angle ε

Basic equation:

$$\text{hav } \varepsilon = \frac{\sin \left(\frac{m - b + c}{2} \right) \left[\sin \left(\frac{m + b - c}{2} \right) \right]}{\sin b \ (\sin c)}$$

$$\log \sin \left(\frac{m - b + c}{2} \right) =$$
$\log \sin (30 \text{ deg } 10.2 \text{ min}) = 9.70119\text{-}10$

$$\log \sin \left(\frac{m + b - c}{2} \right) =$$
$\log \sin (35 \text{ deg } 10.2 \text{ min}) = 9.76043\text{-}10$
$\log \csc b = \log \csc (40 \text{ deg}) = 0.19193$
$\log \csc c = \log \csc (35 \text{ deg}) = 0.24141$
By summation, $\log \text{hav } \varepsilon = 9.89496\text{-}10$

$\varepsilon = 124$ deg 46.5 min

2. Corner angle η

Basic equation:

$$\frac{\sin \varepsilon}{\sin m} = \frac{\sin \eta}{\sin c}$$

$$\sin \eta = \sin \varepsilon \ (\sin c) \ (\csc m)$$

$\log \sin \varepsilon = \log \sin (124 \text{ deg } 46.5 \text{ min}) = 9.91456\text{-}10$
$\log \sin c = \log \sin (35 \text{ deg}) = 9.75859\text{-}10$
$\log \csc m = \log \csc (65 \text{ deg } 20.5 \text{ min}) = 0.04153$
By summation, $\log \sin \eta = 9.71468\text{-}10$

$\eta = 31$ deg 13.6 min

Triangle *BAQ*

Design Data:

$a = 10$ deg
$\mu = 180 - \beta - \eta = 93$ deg 9.5 min
$\rho = 180 - \alpha = 60$ deg

Calculations:

1. Sides h and q

Basic equations:

$$\tan \left(\frac{a}{2} \right) \left[\frac{\sin \left(\frac{\mu - \rho}{2} \right)}{\sin \left(\frac{\mu + \rho}{2} \right)} \right] = \tan \left(\frac{q - h}{2} \right)$$

$$\tan \left(\frac{a}{2} \right) \left[\frac{\cos \left(\frac{\mu - \rho}{2} \right)}{\cos \left(\frac{\mu + \rho}{2} \right)} \right] = \tan \left(\frac{q + h}{2} \right)$$

$$\log \tan \left(\frac{a}{2} \right) = \log \tan (5 \text{ deg}) = 8.94195\text{-}10$$

$$\log \sin \left(\frac{\mu - \rho}{2} \right) =$$
$\log \sin (16 \text{ deg } 34.7 \text{ min}) = 9.45534\text{-}10$

$$\log \csc \left(\frac{\mu + \rho}{2} \right) =$$
$\log \csc (76 \text{ deg } 34.7 \text{ min}) = 0.01203$
By summation, $\log \tan \left(\frac{q - h}{2} \right) = 8.40932\text{-}10$

$$\left(\frac{q - h}{2} \right) = 1 \text{ deg } 28.2 \text{ min}$$

$$\log \tan \left(\frac{a}{2} \right) = \log \tan (5 \text{ deg}) = 8.94195\text{-}10$$

$$\log \cos \left(\frac{\mu - \rho}{2} \right) =$$
$\log \cos (16 \text{ deg } 34.7 \text{ min}) = 9.98156\text{-}10$

$$\log \sec \left(\frac{\mu + \rho}{2} \right) =$$
$\log \sec (76 \text{ deg } 34.7 \text{ min}) = 0.63429$
By summation, $\log \tan \left(\frac{q + h}{2} \right) = 9.55780\text{-}10$

$$\left(\frac{q + h}{2} \right) = 19 \text{ deg } 51.7 \text{ min}$$

By simultaneous solution,

$q = 21$ deg 19.9 min
$h = 18$ deg 23.5 min

passing through points B and D, thus forming the two spherical triangles ABD and BCD. The point Q at the intersection of the great circles of links BC and AD forms the third spherical triangle ABQ which enters the calculations.

The first stage of the solution is to find the corner angle β and the side BD of triangle ABD. This calculation involves the case where two sides, a and d, and the included angle, α, are known. One of the haversine equations will be required. The complete calculation is shown in the accompanying *Sample Calculations* which also shows a preferred form of calculation sequence and arrangement designed to facilitate solutions.

The second stage is the solution of the spherical triangle BCD in which the three sides are known. Sides b and c are given in the initial data and side m has been determined in the solution of the spherical triangle ABD. Here, again, an equation involving the haversine may be used as indicated in the solution given in *Sample Calculations*.

The final stage is the solution of the spherical triangle BAQ. In this triangle, two corner angles and the included side are known. Unfortunately, there is no simple approach to this problem which requires determination of the sum and difference of the two unknown sides. The preferred method of calculation is shown in *Sample Calculations*.

For a quick check on the accuracy of the last solution, the following relationships are helpful. From *Fig.* 7, based on the sine law,

$$\frac{\sin \phi}{\sin a} = \frac{\sin \rho}{\sin h} \quad \ldots\ldots (5)$$

$$\frac{\sin \phi}{\sin a} = \frac{\sin \mu}{\sin q} \quad \ldots\ldots (6)$$

Values of the angle ϕ, computed separately from each of these equations, should be identical or in close agreement. Thus, for the problem under consideration, using the values determined in *Sample Calculations*, from Equation 5, ϕ = 28 degrees 27.9 minutes; from Equation 6, ϕ = 28 degrees 27.7 minutes. The small deviation of 0.2 minutes between the computed angles verifies that the solution is correct and illustrates the order of accuracy to be expected when five-place tables are used.

A further rough check is also possible. In any spherical triangle, the sum of the interior angles must be greater than 180 and less than 540 degrees. Also, the sum of any two sides must be greater than the third side. If either of these rules is violated by a given solution, it is obvious that some mistake has been made in the computation. However, this sort of check only indicates gross errors; small errors can only be detected by careful re-examination of the computations.

Finally, the desired angular velocity ratio is determined from Equation 4:

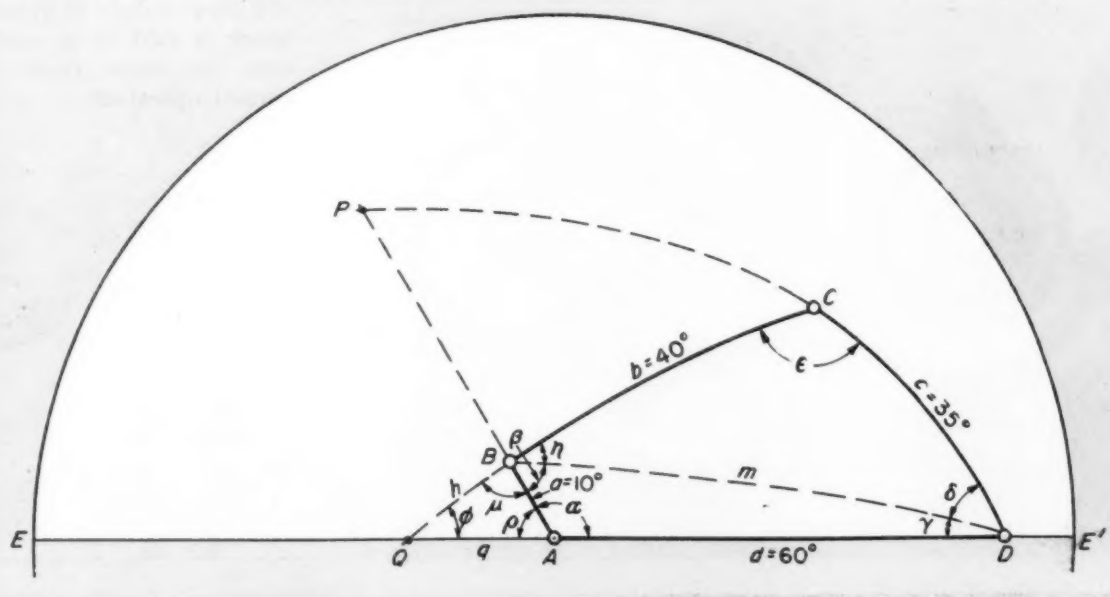
$$\frac{\omega_{AB}}{\omega_{CD}} = \frac{\sin (81 \text{ deg } 19.9 \text{ min})}{\sin (21 \text{ deg } 19.9 \text{ min})} = 2.717$$

The solution, just presented, applies only to one position of the chain (α = 120 degrees). Separate solutions will also have to be made for other values of α. From these data, a velocity diagram for complete cycle can then be constructed in the same manner as for a plane quadric chain.

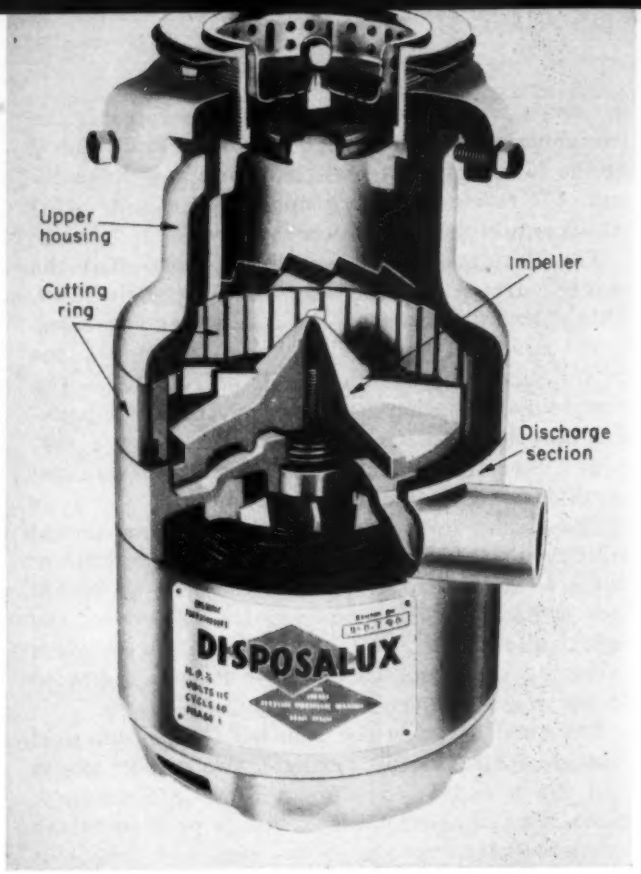
REFERENCES

1. F. R. Erskine Crossley—"3-D Mechanisms," MACHINE DESIGN, Vol. 27, No. 8, August 1955, Page 175.
2. A. B. W. Kennedy—*Mechanics of Machinery*, Macmillan and Co., Ltd., London, England, 1902, Page 496.
3. N. Bowditch—*American Practical Navigator*, H. O. 9, Hydrographic Office, U. S. Navy Dept., Washington, D. C., Table 34.

Fig. 7—Sketch of conical linkage showing typical graphical form for use in analytical solutions



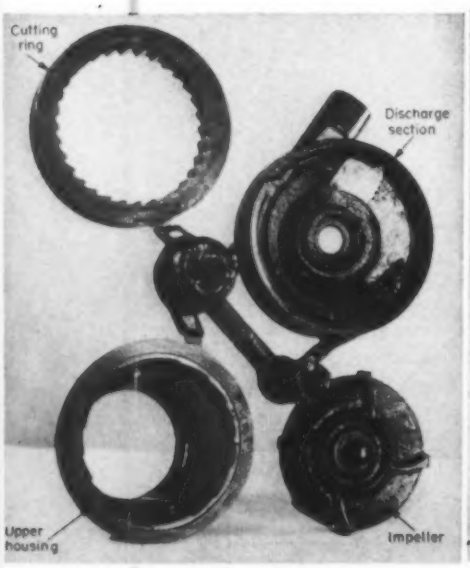
Disposal Unit Uses Shell-Molded Castings

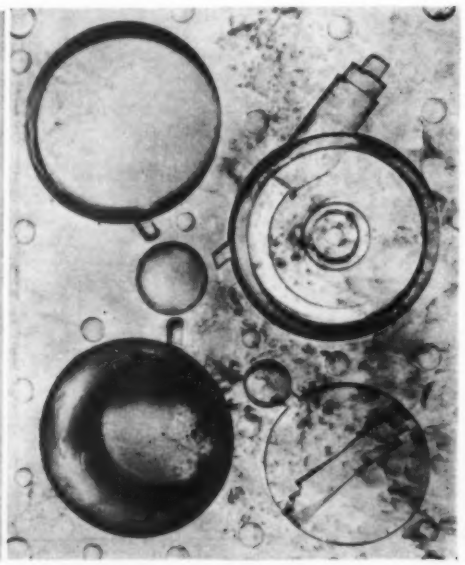


SHELL-MOLDED castings of chromium-molybdenum alloy gray iron are the main components of a recently developed garbage-disposal unit, the Disposalux. Inherent noise-absorbing qualities of cast iron, and the high dimensional accuracy of the shell mold process, were primary reasons for use of this material and technique. Use of the cast components is also said to result in a highly sanitary unit having no interior crevices or cracks in which waste material may collect and decay. Overall size of the unit, made by Disposalux Div., Diamond Machine Tool Co., is 17 in. high and 8 in. diameter. Weight is 44 lb.

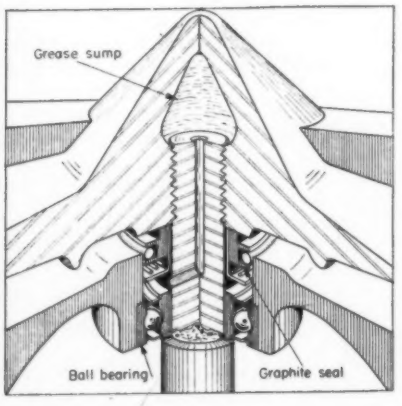
Cutting and grinding of bones, fruit pits and all other food wastes is accomplished by shearing action between the cutting-ring teeth and the integral bars on top of the impeller. Material to be ground is pumped through the grinder by centrifugal pumping action and waste is discharged with sufficient force to keep drain pipes clear. Capacity of the pump at normal motor speed of 1750 rpm is said to be 130 gpm of water. The process is continuous; stopping for refilling is unnecessary.

Details of shell-molded castings are shown by a casting cluster and the drag side of the shell mold. Accuracy of the process is said to be such as to require no machining of the impeller blades or cutting-ring teeth. Cutting edges of the cutting-ring teeth are flame hardened to permit grinding and disposal of all kitchen waste with long tooth life.





A graphite seal is used to prevent water or waste material from entering the motor or bearings. Motor bearings are factory packed for life. A reservoir in the conical portion of the impeller contains an additional supply of grease which is said to be sufficient for seven years of normal operation.



Contemporary Design

MACHINE DESIGN
Data Sheet

Calculations of INVOLUTE GEAR TEETH simplified by tables

By Harold M. Durham
Pittsburgh, Pa.

CALCULATIONS relating to involute gear-tooth profiles, *Fig.* 1, can be simplified by the use of tables and polar co-ordinates. *Fig.* 1*a* shows a base circle and an involute curve. To describe the point P_n on the involute curve, it is necessary to give the radius r_n and the vectorial angle θ_n. A table of values of r_n and θ_n might be useful, but such a tabulation would be limited in use to a given base circle radius. However, a listing of corresponding values of the ratio r_n/r_b and θ_n, as done in *Table* 1, provides a convenient reference for base circles of any radius.

In *Fig.* 1*a*, a second angle ϕ, called the pressure angle is given for reference. The ratio r_n/r_b in *Table* 1 equals the secant of ϕ. While the angle ϕ is related to the vectorial angle θ in radians by the formula $\theta = \tan\phi - \phi = \text{inv}\,\phi$, solutions involving this equation are not required since the relationship is automatically taken care of in *Table* 1.

Fig. 1*b* illustrates the application of the involute curve of *Fig.* 1*a* to a gear tooth. The origin O_1 of the involute is at the base radius of the gear and the pole point O is at the center of the gear. From the origin O_1 the involute curve is identical with the tooth profile.

To illustrate an application of *Table* 1, assume the base radius, r_b is given. For any radius r_n to the involute, evaluate the ratio r_n/r_b and then find the vectorial angle θ_n in radians from *Table* 1. This angle is measured from the origin O_1. Similarly, by reversing the process having an angle θ_n, the corresponding value of ratio r_n/r_b can be found in *Table* 1; from this, the value of radius r_n can be determined.

Often, the value of the angle θ_t in *Fig.* 1*b* is required. This so-called half-tooth angle is subtended by an arc equal to one-fourth the circular pitch or $\theta_t = \pi/2N$ radians. Values of θ_t are tabulated in *Table* 2 for the ideal tooth thickness, i.e., a tooth without backlash or modification. *Examples* 3 and 4 are concerned with tooth-thickness is different than one-half the circular pitch, the half-tooth angle $\theta_t = t_p/2r_p$.

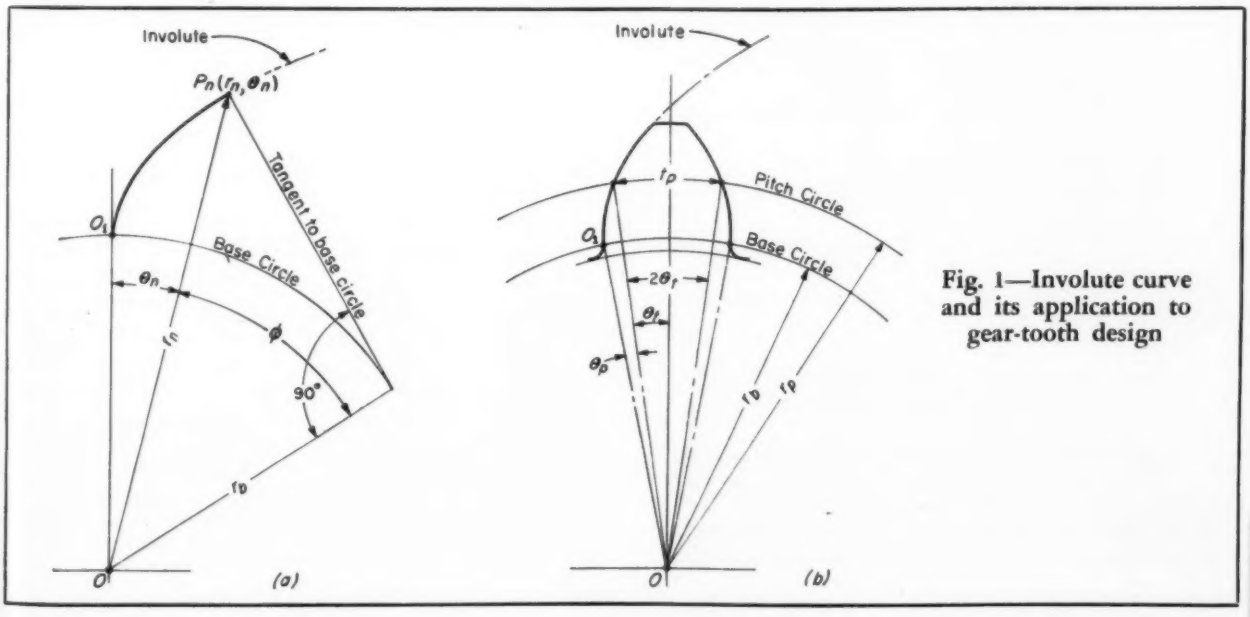


Fig. 1—Involute curve and its application to gear-tooth design

Spur Gears

Six typical design problems involving involute gear teeth are presented in *Examples* 1 through 6. Solutions to these example problems show how *Tables* 1 and 2 simplify calculations. *Examples* 1 and 2 deal with tooth width calculations while *Examples* 3 and 4 are concerned with tooth-thickness and center distance evaluations. Span gaging (*Example* 5) and pin measurement (*Example* 6) problems and solutions are given.

While the scope of the examples is limited, they serve to illustrate the advantages of working in polar co-ordinates by using *Tables* 1 and 2, and the simplicity and clarity of the method.

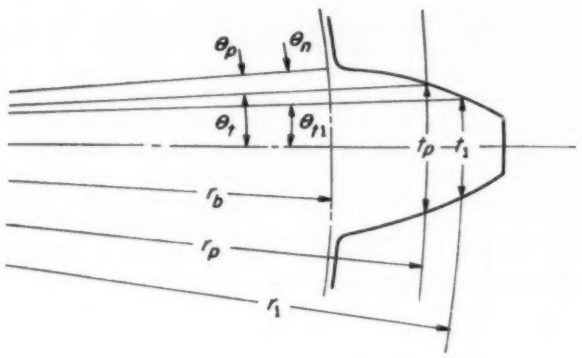
Nomenclature

C = Center distance, in.
D_a = Diameter of circle passing through centers of gaging pins (Example 6), in.
D_b = Diameter of base circle, in.
D_p = Diameter of pitch circle, in.
L = Calculated gage distance across a given number teeth (Example 5), in.
M = Calculated distance across outer extremes of a pair of gaging pins (Example 6), in.
$= D_a + 2x$ for external even teeth
$= D_a \cos(90/N) + 2x$ for external odd teeth
$= D_a - 2x$ for internal even teeth
$= D_a \cos(90/N) - 2x$ for internal odd teeth
N = Number of teeth
P_b = Base pitch
P_c = Circular pitch
P_d = Diametral pitch
P_n = Any point on involute curve with polar co-ordinates (r_n, θ_n)
r = Radius vector to involute curve (general), in.
r_b = Radius of base circle (pinion), in.
$= r_p/\sec\phi = r_p \cos\phi$
r_n = Radius vector to any point, P_n, on involute curve, in.
r_o = Outside radius, in.
r_p = Radius of pitch circle, in.
S = Number of spaces between N teeth
t_n = Arc tooth thickness at any radius, r_n, other than r_p, in.
$= 2r_n\ \theta_{tn}$
t_p = Circular tooth thickness (at pitch radius), in.
x = Radius of measuring pin, in.
ϕ = Pressure angle of teeth, cutter, etc., degrees or radians
θ = Vectorial angle (general), radians
$= \tan\phi - \phi = \text{inv}\phi$
θ_{bp} = Pitch angle, radians
θ_n = Vectorial angle to any point, P_n, on involute curve, in.
θ_p = Vectorial angle at pitch circle, radians
θ_t = Half-tooth angle, radians
$= \pi/(2N)$ with zero backlash (values in *Table* 2)
$= t_p/(2\ r_p)$
θ_{tn} = One-half the angle subtended by any arc tooth thickness (t_n), radians
$= \theta_p + \theta_t - \theta_n$
θ_x = Angle subtended by distance x (gaging-pin radius) along base circle, radians
Secant $\phi_n = r_n/r_b$ (values in *Table* 1)
Subscripts: G denotes gear; P denotes pinion; R denotes rack; 1, 2, 3, etc., denote specific n points.

Table 1—Radii Ratios

Radii Ratio $r_n/r_b = \sec\phi$	Vectorial Angle θ_n (radians)	diff.	Radii Ratio $r_n/r_b = \sec\phi$	Vectorial Angle θ_n (radians)	diff.
1.002	0.000084	154	1.110	0.032812	2149
1.004	0.000238	199	1.115	0.035003	2191
1.006	0.000437	235	1.120	0.037235	2232
1.008	0.000672	267	1.125	0.039506	2271
1.010	0.000939	294	1.130	0.041816	2310
1.012	0.001233	319	1.135	0.044162	2346
1.014	0.001552	342	1.140	0.046545	2383
1.016	0.001894	364	1.145	0.048963	2418
1.018	0.002258	385	1.150	0.051416	2453
1.020	0.002643	404	1.155	0.053901	2485
1.022	0.003047	421	1.160	0.056420	2519
1.024	0.003468	439	1.170	0.061549	5129
1.026	0.003907	456	1.180	0.066799	5250
1.028	0.004363	471	1.190	0.072165	5366
1.030	0.004834	487	1.200	0.077639	5474
1.032	0.005321	501	1.210	0.083219	5580
1.034	0.005822	516	1.220	0.088898	5679
1.036	0.006338	530	1.230	0.094674	5776
1.038	0.006868	542	1.240	0.100542	5868
1.040	0.007410	554	1.250	0.106499	5957
1.042	0.007966	568	1.260	0.112541	6042
1.044	0.008534	581	1.270	0.118666	6125
1.046	0.009115	593	1.280	0.124869	6203
1.048	0.009708	603	1.290	0.131149	6280
1.050	0.010311	616	1.300	0.137503	6354
1.052	0.010927	627	1.320	0.150421	12918
1.054	0.011554	637	1.340	0.163606	13185
1.056	0.012191	648	1.360	0.177042	13436
1.058	0.012839	658	1.380	0.190712	13670
1.060	0.013497	668	1.400	0.204602	13890
1.062	0.014165	679	1.420	0.218702	14100
1.064	0.014844	688	1.440	0.232998	14296
1.066	0.015532	697	1.460	0.247480	14482
1.068	0.016229	707	1.480	0.262139	14659
1.070	0.016936	716	1.500	0.276965	14826
1.072	0.017652	725	1.550	0.314710	37745
1.074	0.018377	734	1.600	0.353335	38625
1.076	0.019111	743	1.650	0.392742	39407
1.078	0.019854	751	1.700	0.432851	40109
1.080	0.020605	1914			
1.085	0.022519	1965	**Special Values**		
1.090	0.024484	2014	$r_n/r_b =$ sec ϕ	θ_n (radians)	ϕ (deg)
1.095	0.026498	2060	1.03290	0.005544	14.5
1.100	0.028558	2105	1.06418	0.014904	20.0
1.105	0.030663	2149	1.08239	0.021514	22.5
			1.10338	0.029975	25.0

Example 1



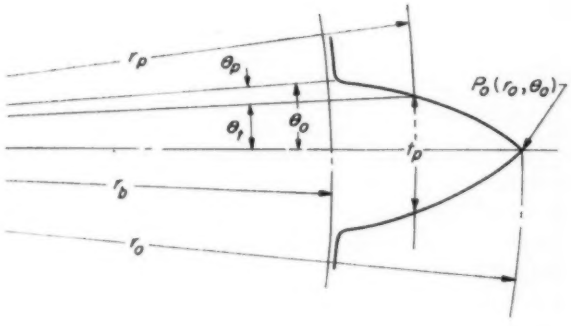
Problem: Find tooth thickness t_1 at radius r_1.

Given: $N_P = 21$, $P_d = 3$, $\phi = 20$ deg, $r_p = 3.5$ in., $t_p = 0.5236$-in., $r_p/r_b = 1.06418$, $r_1 = 3.7$ in.

Solution: From the nomenclature, $t_1 = 2r_1\ \theta_{t1}$ and $\theta t_1 = \theta_p + \theta_t - \theta_n$. For $\phi = 20$ deg, from the special values section of *Table* 1, $\theta_p = 0.014904$-radian. With zero backlash*, $\theta_t = \pi/2N$ or from *Table* 2 for 21 teeth, $\theta_t = 0.074799$-radian. The sum $\theta_p + \theta_t = 0.089703$-radian. From the nomenclature, $r_1/r_b = r_1 (r_p/r_b)/r_p = 3.7\ (1.06418)/3.5 = 1.125$; using this value of r_1/r_b in *Table* 1, $\theta_1 = 0.039506$-radian. Thus $\theta_p + \theta_t - \theta_1 = \theta_{t1} = 0.050197$-radian. Therefore $t_1 = 2r_1\ \theta_{t1} = 2\ (3.7)\ (0.050197) = 0.37146$-in.

*When t_p is not standard (backlash not zero), formula $\theta_t = t_p/2r_p$ must be used.

Example 2



Problem: Find radius r_o at which top of tooth has a minimum value.

Given: $N_p = 21$, $P_d = 3$, $\phi = 20$ deg, $r_p = 3.5$ in., $t_p = 0.5236$-in., $r_p/r_b = 1.06418$.

Solution: $\theta_o = \theta_p + \theta_t$ and $r_o = r_p\ (r_o/r_b)/(r_p/r_b)$. For $\phi = 20$ deg, from the special values section of *Table* 1, $\theta_p = 0.014904$-radian. With zero backlash*, $\theta_t = \pi/2N$ or from *Table* 2 for 21 teeth, $\theta_t = 0.074799$-radian. Thus, $\theta_o = \theta_p + \theta_t = 0.089703$-radian. For this θ_o, the corresponding r_o/r_b from *Table* 1 = 1.2214. Using the above formula, $r_o = 3.5\ (1.2214)/1.06418 = 4.017$ in.

*When t_p is not standard (backlash not zero), formula $\theta_t = t_p/2r_p$ must be used.

Table 2—Half-Tooth Angles for Gears with *N* Teeth and Zero Backlash

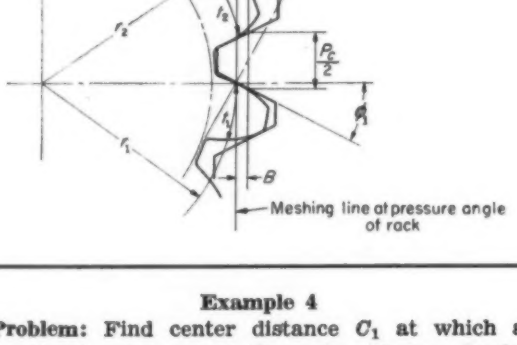
Number of Teeth *N*	Half-Tooth Angle $\theta_t = \pi/2N$ (radians)	Number of Teeth *N*	Half-Tooth Angle $\theta_t = \pi/2N$ (radians)	Number of Teeth *N*	Half-Tooth Angle $\theta_t = \pi/2N$ (radians)	Number of Teeth *N*	Half-Tooth Angle $\theta_t = \pi/2N$ (radians)
		36	0.0436332	71	0.0221239	106	0.0148188
		37	0.0424540	72	0.0218166	107	0.0146803
		38	0.0413367	73	0.0215178	108	0.0145444
		39	0.0402768	74	0.0212270	109	0.0144110
5	0.3141593	40	0.0392699	75	0.0209440	110	0.0142800
6	0.2617994	41	0.0383121	76	0.0206684	111	0.0141513
7	0.2243995	42	0.0373999	77	0.0204000	112	0.0140250
8	0.1963495	43	0.0365301	78	0.0201384	113	0.0139009
9	0.1745329	44	0.0356999	79	0.0198835	114	0.0137789
10	0.1570796	45	0.0349066	80	0.0196350	115	0.0136591
11	0.1427997	46	0.0341477	81	0.0193925	116	0.0135413
12	0.1308997	47	0.0334212	82	0.0191561	117	0.0134256
13	0.1208305	48	0.0327249	83	0.0189253	118	0.0133118
14	0.1121997	49	0.0320571	84	0.0187000	119	0.0132000
15	0.1047198	50	0.0314159	85	0.0184800	120	0.0130900
16	0.0981748	51	0.0307999	86	0.0182651	121	0.0129818
17	0.0923998	52	0.0302076	87	0.0180551	122	0.0128754
18	0.0872665	53	0.0296377	88	0.0178500	123	0.0127707
19	0.0826735	54	0.0290888	89	0.0176494	124	0.0126677
20	0.0785398	55	0.0285599	90	0.0174533	125	0.0125664
21	0.0747998	56	0.0280499	91	0.0172615	126	0.0124666
22	0.0713998	57	0.0275578	92	0.0170739	127	0.0123685
23	0.0682955	58	0.0270827	83	0.0168903	128	0.0122718
24	0.0654498	59	0.0266237	94	0.0167106	129	0.0121767
25	0.0628319	60	0.0261799	95	0.0165347	130	0.0121830
26	0.0604152	61	0.0257508	96	0.0163625	131	0.0119908
27	0.0581776	62	0.0253354	97	0.0161938	132	0.0119000
28	0.0560999	63	0.0249333	98	0.0160285	133	0.0118105
29	0.0541654	64	0.0245437	99	0.0158666	134	0.0117224
30	0.0523599	65	0.0241661	100	0.0157080	135	0.0116355
31	0.0506708	66	0.0237999	101	0.0155524	136	0.0115500
32	0.0490874	67	0.0234447	102	0.0154000	137	0.0114657
33	0.0475999	68	0.0230999	103	0.0152504	138	0.0113826
34	0.0461999	69	0.0227652	104	0.0151038	139	0.0113007
35	0.0448799	70	0.0224399	105	0.0149600	140	0.0112200

Example 3

Problem: Determine position of a mating rack to spur gear of different circular pitch and pressure angle.

Given: For the rack—$P_{cR}/2 = 0.31416$-in., $\phi_1 = 20$ deg, and $A = 0.2$. For the gear—$r_2 = 4.097$ in., $t_2 = 0.2733$-in., $\phi_2 = 23.45$ deg.

Solution: From *Table* 1, $r_1/r_b = \sec \phi_1 = 1.06418$ and the corresponding $\theta_1 = 0.014904$-radian, $r_2/r_b = \sec \phi_2 = 1.09$ and the corresponding $\theta_2 = 0.024484$-radian. Since $r_1/r_2 = \sec \phi_1/\sec \phi_2$, pinion radius $r_1 = r_2 \sec \phi_1/\sec \phi_2 = 4.097\ (1.06418)/1.09 = 4.000$ in. It can be shown that $t_1/2r_1 + \theta_1 = t_2/2r_2 + \theta_2$ or $t_1 = 2r_1\ (t_2/2r_2 - \theta_1 + \theta_2) = 2\ (4)\ [0.2733/(2 \times 4.097) - 0.014904 + 0.024484] = 0.34346$-in. Distance $B = (t_1 - P_{cR})/2 \tan \phi_1 = (0.34346 - 0.31416)/2\ (0.36397) = 0.04025$-in. From the diagram, $D = r_1 - A + B = 4 - 0.2 + 0.04025 = 3.84025$-in.

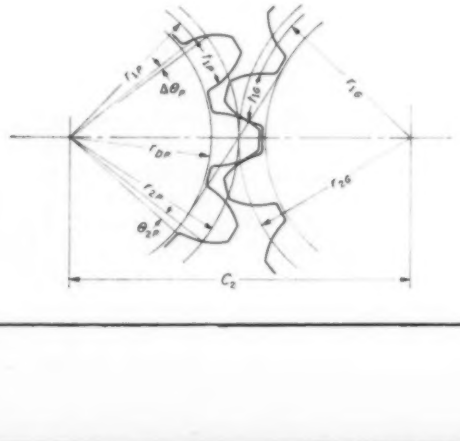


Example 4

Problem: Find center distance C_1 at which a pair of spur gears will mesh with zero backlash.

Given: Standard pinion radius—$r_{1P} = 3.500$ in., standard gear radius—$r_{1G} = 5.000$ in., standard center distance—$C_1 = 8.500$ in., $t_{1P} = 0.2800$-in., $t_{1G} = 0.2750$-in., standard pressure angle—$\phi_1 = 20$ deg, $P_d = 6$, $P_c = 0.5236$, $r_{1P}/r_{bP} = r_{1G}/r_{bG} = 1.06418$.

Solution: $\Delta\theta_p = \Delta t_p/2C_1$ where $\Delta t = t_{1P} + t_{1G} - P_c$. Thus, $\Delta\theta_p = (0.2800 + 0.2750 - 0.5236)/17 = 0.001847$-radian. At the "operating" pitch circle radius, r_{2P}, the corresponding vectorial angle $\theta_{2P} = \theta_{1P} + \Delta\theta_P$ where θ_{1P} is the vectorial angle for standard pressure angle, ϕ_1. From the special values section of *Table* 1, $\theta_{1P} = 0.014904$-radian. Thus $\theta_{2P} = \theta_{1P} + \Delta\theta_P = 0.014904 + 0.001847 = 0.016751$-radian. Applying this θ_{2P} in *Table* 1, $r_{2P}/r_{bP} = 1.06948$. Therefore, $C_2 = C_1\ (r_{2P}/r_{bP})/(r_{1P}/r_{bP}) = 8.500\ (1.06948)/1.06418 = 8.5425$-in.

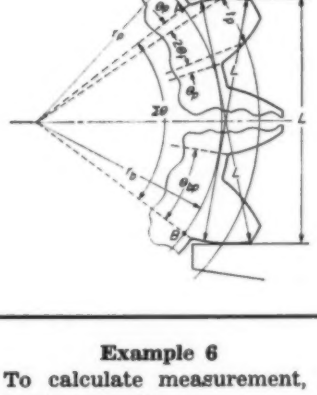


Example 5

Problem: To calculate measurement L over a given number of teeth for span gaging.

Given: $r_p = 47.250$ in., $\phi = 20$ deg, $t = 0.775$-in., $N = 189$.

Solution: Maximum number of spaces for $\phi = 20$ deg for a gear with odd number of teeth is given by formula $S = N/(180/\phi) - 1$ where ϕ is in deg. Thus, $S = 189/9 - 1 = 20$ spaces. For 20 spaces, distance $L = r_b\ (\Sigma\theta) =$ arc AB. Radius $r_b = r_p \cos (20\ \text{deg}) = 47.250\ (0.9397) = 44.400$ in. The value of $\Sigma\theta = 2\ \theta_p + 2\ \theta_t + 20\ \theta_{bp}$. From *Table* 1 using the value of r_p/r_b, $\theta_p = 0.014904$-radian. The angle $\theta_t = t_p/2r_p = 0.775/94.50 = 0.008201$-radian. The angle $\theta_{bp} = 2\pi/189 = 0.0332444$-radian. Thus, $\Sigma\theta = 2\ (0.014904) + 2\ (0.008201) + 20\ (0.0332444) = 0.711098$-radian. Therefore $L = 44.400\ (0.711098) = 31.5727$-in.

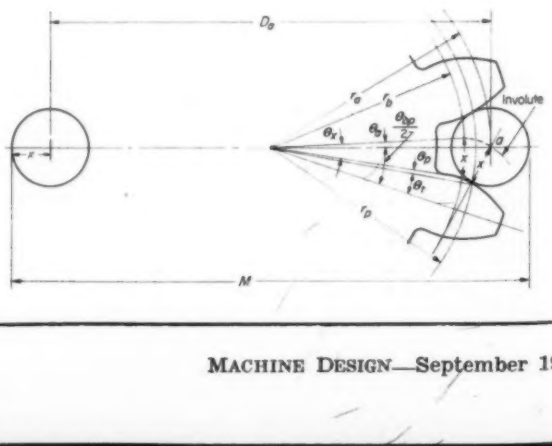


Example 6

Problem: To calculate measurement, M, using measuring pins of radius x.

Given: $r_p = 3.500$ in., $t_p = 0.2618$-in., $\phi = 20$ deg, $N = 42$, $x = 0.1406$ in.

Solution: From the nomenclature $M = D_a + 2x$ or $M/2 = r_a + x$. By determining θ_a the value of r_a can be found. Radius $r_b = 3.500 \cos(20\ \text{deg}) = 3.500\ (0.93969) = 3.28891$. Angle $\theta_x = x/r_b = 0.1406/3.28891 = 0.042749$-radian. From *Table* 1 using value of r_p/r_b, $\theta_p = 0.014904$-radian. Angle $\theta t = t_p/2r_p = 0.2618/7.000 = 0.37400$-radian. Angle $\theta_{bp}/2 = \pi/N = \pi/42 = 0.074800$-radian. Thus, $\theta_a = \theta_x + \theta_p + \theta_t - \theta_{bp}/2 = 0.042749 + 0.014904 + 0.037400 - 0.074800 = 0.020253$-radian. From *Table* 1 using the value of θ_a in radians, find $r_a/r_b = 1.07906$. Thus, $r_a = r_b\ (1.07906) = 3.28891\ (1.07906) = 3.548931$ in. Therefore, $M/2 = r_a + x = 3.548931 + 0.1406 = 3.689531$ in. or $M = 7.37906$ in.



Using Steel Castings in Weldments

DESIGN ABSTRACTS

How to save cost by welding steel castings together or to rolled, forged or stamped sections

By E. J. Wellauer
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STEEL castings as components of weldments are used widely because of possible savings in cost. They are likely to be advantageous in regard to quality production, useful properties and simplified design.

Casting: Both soundness and cost of a casting depend primarily upon mechanical design. Lower factors of safety are possible for designs in which the casting is within specified quality limits. Use of welding makes it easier to obtain a required quality level.

When metal enters a mold during casting, it should flow with a minimum of disturbance. Appendages which agitate the flow should not be used. Thin cores or dividing walls which might spall when subject to hot metal are to be avoided. These walls can be welded plate inserts, thereby allowing full strength to be used in design computations.

Because of differences in solidification temperatures and fluidity, minimum section thickness which can be poured with reliability is limited. Values suggested for cast steel by the Steel Founders' Society of America† are shown in *Fig.* 1. Obviously, if thicknesses below these are needed for minimum weight or other functional reasons, use of thin sheet or plate welded into place fulfills the engineering requirement. As an example, the machine base in *Fig.* 2 was initially a two-piece casting designed to reduce section thickness by reducing the major flow dimension. Because of the two-piece design, four tie bars were required to carry the load satisfactorily. In the redesign, plates were substituted for cast walls and a one-piece base resulted which, because of the increased section modulus, required only two tie bars. Use of steel castings was limited to those portions of the base better suited for this method of production.

Most steel castings have risers which are reservoirs to compensate for fluid metal shrinkage and also to act as heat-gradient regulators to control directional and progressive solidification. If these two functions are not completely fulfilled, internal defects are likely to occur, which must be consid-

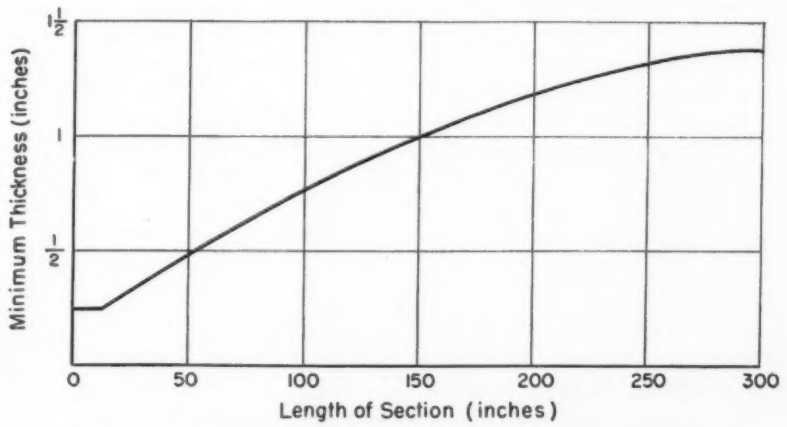

Fig. 1—Minimum thickness of cast-steel sections as a function of their largest dimension

†*Steel Castings Handbook*, 1950, Steel Founders' Society of America, Cleveland, Ohio. (See also *Recommended Practice for the Welding of Steel Castings*, Steel Founders' Society of America, 1951—Ed.)

ered when selecting design stresses or loading. When the riser must feed an excessive length for the section thickness involved, various foundry techniques such as "padding" or "wedging" can be used, augmented by chills, if necessary. A long tube of relatively thin section would be typical of a statically cast structure presenting insurmountable difficulties in feeding properly to get soundness through the length and across the section. If overall machining is required, particularly to considerable depth, consideration would have to be given to the design.

Hot tears are another casting defect which can be minimized by careful design. Hot tears result from temperature gradients which establish different rates of contraction during solidification, thus inducing stresses because resistance of the sand is sufficient to cause fracture. Abrupt changes in section, sharp angles and nonuniform webs connected to flanges are possible stress locations and sources of hot tears. Where hot tears are known to exist and cannot be tolerated, costly inspection and repair are required if the section is to be stressed efficiently. Possibility of a hot tear is eliminated by composite design. A structure consisting of separate castings welded together can often assure perfect sections, enabling the highest allowable design stresses to be used.

When light and heavy sections join in a casting, it is sometimes costly and difficult to obtain sound metal. The highest localized stress is usually developed at the abrupt changes in section. If a proper taper cannot be provided, the light section can be joined by welding.

Easier molding, founding and cleaning resulting from simple castings welded together or to fabricated forms can often result in superior engineering performance because of the improved quality resulting from more reliable and thorough inspection. Furthermore, higher quality standards of acceptance can be more economically justified for small subcastings whose scrappage would involve less cost than that of a large single component.

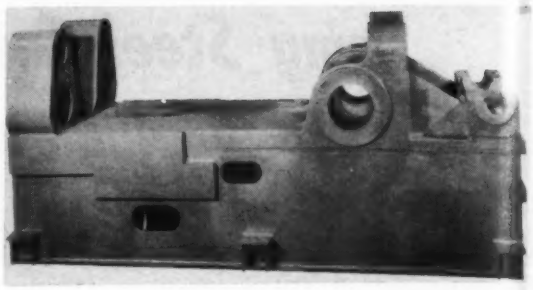

Fig. 2—Machine base formed of castings welded to plates is more satisfactory than original two-piece casting

Welding: Start of a weld can be of low quality. In many highly stressed parts, this first portion (particularly for automatic welds) is chipped out and rewelded. When a large number of short welds are indicated by preliminary design studies, it is desirable to direct final design to a steel casting and get better properties which, in turn, can lead to further reduction in factors of safety and in cost. In fact, some of the best reductions in cost are secured with steel casting for parts which, if of welded construction, would require many short welds. In addition, numerous short or unconventionally located welds require considerable positioning if quality is to be maintained.

Unless proper penetration is obtained in a weld, lower joint strength must be accepted. Hard-to-weld configurations can often be easily made in steel castings with simple cores and should be considered where maximum stress efficiency is required.

Distortion and locked-up residual stresses which can have an

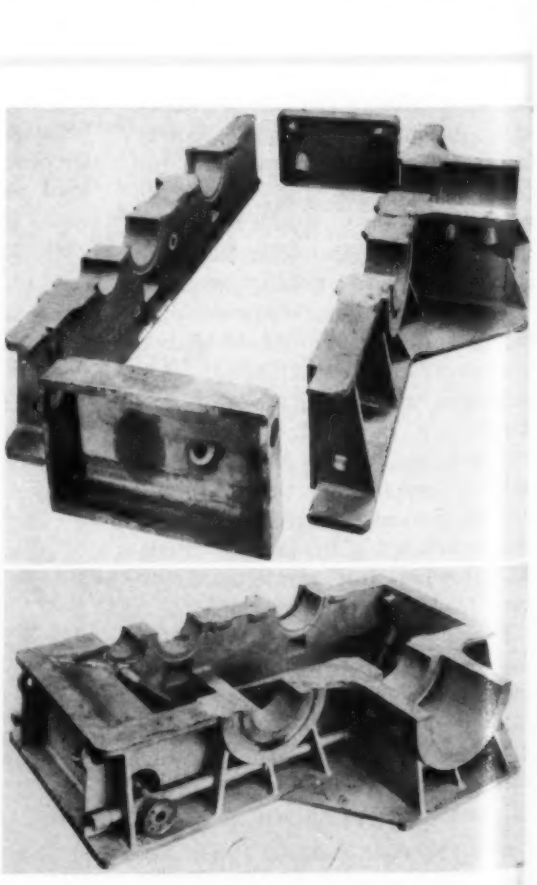

Fig. 3 — Gear case composed of castings, top, is welded into completed form with addition of plates and pipes, below

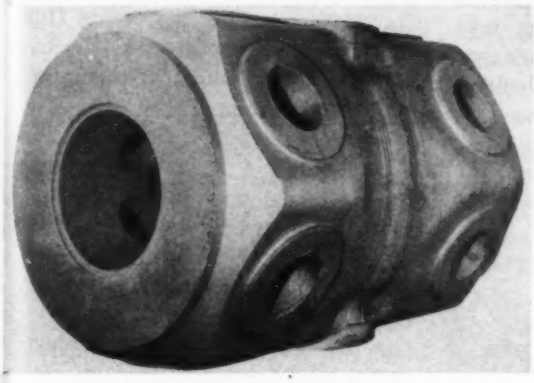

Fig. 4—Pump housing consists of two premachined cast sections joined by a welded band. Casting, cleaning and inspection are simplified

important effect upon load-carrying capacity can be minimized or avoided by properly utilizing steel castings as the keystone of final assembly.

Edge or groove preparation can be reduced by utilizing cast components. An example of a design composed quite largely of castings is shown in *Fig.* 3. The weld scarf was cast, requiring only a simple grind for final preparation. The flat components required a minimum foundry flask size and because of simpler feeding were of improved quality. Addition of plates and pipes welded to the subcastings produced the completed case.

Machining: With cost savings inherent with steel castings, quality can be assured by premachining importantly stressed surfaces for minute inspection. The pump housing shown in *Fig.* 4 is a typical example. Necessity for having complex internal passages which would be difficult to cast, clean and inspect caused the casting to be designed in two sections joined by a welded band. The two halves were premachined, which allowed a critical inspection to be made of all important areas. Subcastings sometimes can be premachined on smaller machines. Sufficiently low hourly rates warrant the operation because better inspection is made possible.

When large, flat areas are to be machined, the absence of a cast skin and more closely controlled finish stock are advantages for steel plate. These advantages can be secured in the finished design by properly welding castings to the plate.

Properties: Range of physical properties or chemical compositions commercially available in plate and other rolled materials is limited. For steel castings these limitations are not as restrictive. The smaller sized heats normally used for castings allow greater flexibility, and the engineer can select an analysis which, with proper heat treatment, can meet exact design needs at minimum cost.

Most steel castings have a higher tensile strength than rolled products of similar carbon composition. This is due to the manganese and silicon content usually acquired in the foundry.

Usefulness of high-strength steels at the locations in a weldment having the highest stress is obvious. The practice has been universally used for bolted and other types of assemblies. A typical example of the practice is a large gear wheel. The outer rim into which the heavily stressed teeth are cut is an alloy cast steel. The arm portion is a plain carbon steel. After final heat treatment, the tensile and endurance properties in the rim are higher than in the arm portion due to response of the alloy to heat treatment. The same process has been used when high hardnesses are required at a localized area to resist wear.

Use of a steel casting is particularly merited with a complex configuration. Hazards of extensive welding on wear-resisting high alloy can be minimized by reducing welding to the joint with the main weldment, which joint should be maintained at a minimum length and designed with the least possible restraint.

In like manner, the selection of a material with required ductility, toughness or impact resistance can be provided by appropriate use of a casting or a plate at the proper location. Use of fully killed steels normal to the casting process sometimes provides a more adequate transition temperature in the material which can resist brittle crack propagation or other forms of brittle failure.

Casting is an ideal manner in which to form steels of analyses which might be difficult, if not impossible, to form by pressing, rolling or similar procedures.

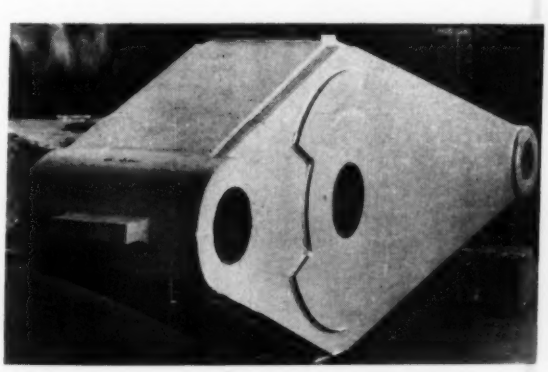

Fig. 5—Yoke is made of wrapper plates welded to castings to form an enclosed box section

Metallurgical properties, such as hardenability, weldability, carburizing, etc., are similar for cast, rolled and wrought steels of identical analysis. This fact allows the designer to evaluate steel castings as part of a weldment on the basis of cost as well as properties.

Design: Since casting is a means of forming materials, one of its outstanding characteristics is the ease with which desired shapes, curves, etc., can be obtained. This is an advantage because it allows liberty to obtain a pleasing appearance. On the functional side, the ability to streamline is of considerable value for parts carrying a flowing fluid, to minimize turbulence, increase flow capacity and decrease power requirements.

An outstanding use of castings combined in a weldment is where design revisions might have to be made. These revisions might become necessary because of field experiences or changes in requirements or specifications, as well as for inventory control of nonsymmetrical designs. Right and left-hand components can be made from common castings and plates, with nonsymmetrical features added during assembly or by welding as required.

For designs requiring a minimum of deflection, particularly when weight reductions are desired, a skillful combination of castings or plates most easily produces the required section modulus. For example, flat surfaces at a distance from the neutral axis can easily increase the section modulus to required values with thicknesses considerably below those which can be cast successfully. The removal of cores for casting an enclosed box section might be impossible or expensive. In these cases, a light rolled plate welded to the casting fulfills the function. When a skin must be light enough to deflect sufficiently to act as a Wagner beam or

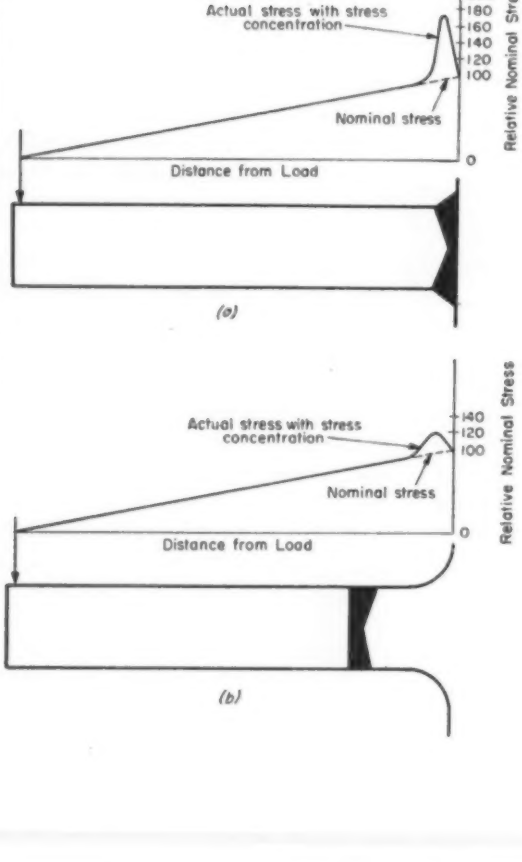

Fig. 6 — Stress concentration is accentuated by locating weld at change in section, *a*, and minimized by placing weld away from high stress location, *b*

Fig. 7—Design revision of welded structure, left, led to lower stress concentrations of smoothly contoured castings, right

stressed skin construction, the thickness required for casting might defeat the function. Here a light wrapper plate as used in the yoke, *Fig.* 5, serves satisfactorily.

Redesigning a structure from cast iron to steel usually raises the question of noise or vibration. Much is made of the damping capacity of cast iron, when in reality the troubles which have been experienced have been due to improper attention to design considerations of the elastic system. The proper approach can be illustrated as follows:

An equation for the frequency of vibration of rectangular plates* is:

$$w_i = \sqrt{\frac{E}{12\,\rho\,(1 - V^2)}} \left(\frac{h}{a^2}\right) k_i \qquad (1)$$

where a = length of shorter side of plate; b = length of longer side of plate; w_i = frequency of vibration for a certain mode; k_i = constant corresponding to the mode, the ratio b/a, and the edge support condition; h = thickness of the plate; E = Young's modulus of elasticity; ρ = density of plate material; and V = Poisson's ratio of plate material.

The ratio of the thickness between a steel and a cast iron plate with the same dimensions a and b giving the same frequency for any mode of vibration can be found from Equation 1. The ratio is 0.77. Since the changes from cast iron to steel usually involve reduction in section of from 4 to 10, increased frequencies are to be expected. The problem can be eliminated by designing the plate dimensions and thickness or boundary conditions so as to move the natural frequencies away from the forcing frequencies, or at least to lower the tone to a frequency less objectionable to the human ear. Adequate design made possible with the freedom allowed by combining castings in a weldment (or plate in a casting) enables vibrations to be suppressed.

These problems of contour and other performance characteristics are helpful tools for the progressive designer. However, the control of such things as stress concentration by the combination of steel castings in a weldment can have a powerful influence upon design, performance and cost of a machine element.

Stress concentration in service can be encountered at changes in section similarly to that shown in *Fig.* 6*a*. The stress at the fillet can be 1.5 to 3 times the nominally computed stress, decreasing with increasing radii size. Therefore, changes in design to reduce stress concentration by means of a larger fillet easily obtainable in a casting can provide a greater increase in strength than is economically possible by changes in material and heat treatment.

The raw weld bead in itself has a high stress-concentration factor. The effect of this rough surface can be minimized by grinding flush or placing the weld away from the location of high stress concentration, *Fig.* 6*b*. The stub can easily be made a part of a casting, providing the largest radii, having a cast scarf, and even being of a higher strength material than normal plate to carry the higher localized stress. These techniques are all used in the cast-steel bearing ends of the yoke, *Fig.* 5. The center hub is also a steel casting premachined before welding.

Advantage of the lower stress concentration of a smoothly contoured casting was realized in the design revision of the large structure shown in *Fig.* 7. Note that a flange was added to the casting to increase strength and rigidity, although plate and welding were still retained where they were technically most effective or economical.

From a paper entitled "Steel Castings—Their Engineering Advantages in Weldments" presented at the 59th annual convention of American Foundrymen's Society in Houston, Texas, May, 1955.

*R. F. S. Hearman—"The Frequency of Vibration of Rectangular Isotropic Plates." *Transactions of ASME*, Vol. 74, 1952.

Picking the Right Relay

By E. H. Lockwood

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RELAYS are now commonplace components, and have to meet widely different conditions of temperature, pressure, shock and vibration. Most of the reasons why relays, in general, can not be equalled in cost by another component are that they:

1. Can switch large amounts of power with small size.
2. Are available in multicontact arrangements.
3. Can be obtained in a wide variety of contact combinations.
4. Can have sequenced contacts; contacts can be made slow operate, slow release, etc.
5. Respond to changes in polarity, voltage or current for wide variety of uses.
6. Can have high sensitivity in single-pole designs.

Unfortunately, no one universal relay exists that will fulfill all requirements. Therefore, in applying or using relays some care is necessary to insure the use of the right relay. Sometimes, during development of equipment, an initially suitable relay may later need to be changed to another type because of circuit changes found necessary during equipment development. This may pose a very difficult situation, often embarrassing to the relay manufacturer who must decide when the borderline between two types has been crossed.

Voltage-Operated Relays: Relays for these applications have at least

the full minimum voltage applied to operate them, and the voltage is removed completely for release. A release or drop-out value is frequently specified to avoid failure to release due to residual magnetism or to provide hold-in down to a certain voltage value to meet circuit conditions of a momentary or short-duration nature.

This group of relays can be considered as including power relays for both dc and ac, coaxial relays, and a wide variety of other types.

In order for the relay to meet its requirements, it must pull in and drop out within limits over the specified temperature range. Resistance of copper wire increases with an increase in temperature by about 0.00393-ohm per degree C for each ohm of resistance, and this becomes a design limit for some relays when considered for use at 125 C and higher. The magnitude of the change and the variation in watts at 28 volts is shown by *Table* 1. For the relay to ignore this change and operate at the high resistance without overheating at the low resistance becomes quite a problem.

The relay manufacturer usually tests relays at room temperature and applies a voltage lower than the minimum value specified, by an amount such that minimum voltage will operate the relay with the resistance resulting from the maximum specified ambient temperature. When relays must operate at high ambient temperature the result is sometimes an overheating at room temperature with maximum specified voltage.

An obvious result of this wide change in power is that the operate time and, to a lesser extent, the release time vary widely over the temperature range. A typical small telephone type relay may vary over limits shown in *Table* 2.

In most cases this temperature characteristic of copper wire must be met by designing the relay with enough margin to permit operation at the ampere-turns available at the high temperature.

Occasionally an application difficulty can be resolved by the use of a thermistor or other nonlinear resistanee medium. The positive temperature coefficient of copper can be matched by an approximately equal negative temperature coefficient. With the two elements connected in series, the applied voltage will meet an almost constant resistance over the entire temperature range. The transistor usually has to be wound into the coil for proper temperature response. A disk form is convenient, since it can be located at the end of the coil or bobbin.

Wire having a substantial zero temperature coefficient of resistance is available, but its specific resistance is so high that an impractically high dc voltage would be needed to provide sufficient ampere turns to operate the relay. One such alloy with 55 per cent copper and 45 per cent nickel has a resistivity of 49 microhm-cm compared with 1.71 microhm-cm for copper. Its temperature coefficient of resistance however is 0.00002 per degree C compared with 0.00393 for copper.

Voltage-operated relays are characterized by good snap action on operate and release because the current or voltage at which operation might be marginal, with a tendency to creep, is always below the minimum specified voltage. This extra amount of power also improves the ability of the relay to meet shock and vibration and makes multicontact arrangements feasible. Gaining these characteristics, however, means sacrificing others, since a narrow differential between pull-in and drop-out is usually impossible.

Table 1—Effect of Temperature Changes on Typical Relay Coil*

Ambient Temperature (C)	Resistance (ohms)	Coil Power† (watts)
— 65	66	7.84
20	126	6.21
85	141	5.55
125	171	4.58
200	11.9	...

*Coil resistance—100 ohms at 20 C. †At 28 volts dc.

Table 2—Operating Time for Typical Relay*

Temperature (C)	Time (seconds)
— 65	0.017
20	0.015
85	0.014
125	0.013

*At 28 volts dc.

From the users standpoint, the following features determine the application of voltage-operated relays:

1. Power used decreases as temperature increases, and nonoperate point may be reached at the upper temperature limit.
2. Operate and release times must be specified at a given temperature since they vary widely over the temperature range.
3. Relays have good snap action on operate and release.
4. They are suitable for multicontact operation.
5. Relays have good resistance to shock and vibration when armature is balanced reasonably well.
6. Pull-in and drop-out must be specified as maximum or minimum.
7. Narrow differential between operate and release is not usually possible.
8. Relays are relatively inexpensive because of ease in adjustment.

Current-Operated Relays: This group of relays may include plate-circuit uses, overcurrent or undercurrent—any application when the pull-in or drop-out values, or both, are specified as a given value of current. The basic difference from voltage operation is that there is no margin between the specified operate point and the operate point of the relay, except for the allowed tolerance.

Magnetic relays pull in when a certain critical value of ampere turns have been reached and drop out at some lower value of ampere turns. Therefore, a current-operated relay will pull in or drop out with given current values over a substantial temperature range. This ideal situation is seldom realized precisely, since dimensions and friction change with temperature, and unless special design precautions are taken, the current values are subject to some slight variations with temperature.

As ambient temperature increases, power in the coil increases due to the increase in resistance of copper wire with temperature, even though the coil current remains constant. This may give rise to serious temperature-rise problems at high ambient temperatures. The

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effect of temperature on the operate and release time is much less with a current-operated relay, but is still present. Basic reason is that the change in resistance affects the time constant of the coil during the period when the armature is moving, and as the coil resistance rises, the time constant becomes smaller. This is shown in *Table* 3 using the same relay as in *Table* 2, except that the operate time was taken at 0.035-ampere at each temperature. This value is 5 per cent above the operating value at 20 C.

For many uses, the current to operate or release the relay must be held within a rather small tolerance range. This adds to the difficulty of adjusting the relay, since it is affected by armature air gap, spring tensions and contact gap. Values of drop-out can be raised nearer to pull-in values by using a residual screw, but all of these results are obtained at the expense of operating speed and resistance to shock and vibration, since they are in effect a reduction of the power of the magnetic circuit. Further complications result when the current is a slowly changing one. With this condition, the number of contact springs or poles should be kept to a minimum to reduce the tendency to creep instead of snap. As the current approaches the value needed for pull-in or drop-out, there is always a range of instability for the armature. A load of several contacts widens this range, and difficulty may be experienced in meeting shock or vibration when the operate or release points are approached with a slowly changing current.

Current-operated relays have more restrictive features and parameters than voltage-operated relays:

1. Power used increases as temperature increases and overheating may result at the high temperature.
2. Operate and release current are substantially constant over the temperature range.
3. Operate and release time varies somewhat over the temperature range.
4. There is a tendency to creep with slowly changing current.
5. Pull-in and drop-out can be adjusted to close values with narrow differential between them.
6. First pull-in is usually higher than on subsequent operations.
7. Relays have reduced resistance to shock and vibration near operating point.

Sensitive Relays: So-called sensitive relays are actually low-power relays, and all of their problems stem from that one source. Consequently, a truly sensitive relay would have to be no more than single pole, and this is always the case. Since contact pressure is limited, the single-pole is further restricted to low contact ratings of less than 2 amp in most cases.

In order to take advantage of the sensitivity, air gap, contact gap and spring tensions must be adjusted accurately. This is usually done by adjusting screws, which must be locked in place against loss of adjustment in use. Friction-free pivots for the armature become essential. Uniformity of operation over the required temperature range often results in a study of materials to minimize expansion and contraction of parts which would change the adjustment and to provide mechanical strength and stability of terminal blocks, support brackets, etc.

Coil resistances are apt to be high, since this allows the coil to have enough turns to make up for lack of amperes.

The general group of sensitive relays can be considered as including polarized and meter-element types.

Characteristics of sensitive relays may be summarized as:

1. Contacts are restricted to normally closed, normally open or single pole, double throw.
2. Pull in and drop out can be adjusted accurately.
3. Narrow differential possible between pull in and drop out.
4. Restricted to light contact loads.
5. Reduced resistance to shock and vibration.

Table 3—Operating Time for Typical Relay*

Temperature (C)	Time (seconds)
— 65	0.020
20	0.017
85	0.019
125	0.021

*At 0.035-amp.

Contact Considerations: The subject of contact application cannot be divided into categories, except in very general terms. Silver is the most commonly used of the contact metals, but it and the others are made in large numbers of alloys and mixtures. The requirements of particular applications still are deciding factors in the choice of contact material for relays.

One characteristic is sometimes overlooked—the danger of applying a relay for contact loads too far below the rating of the contacts. Overloading contacts may result in destructive arcing and welding, but too little load will frequently result in lack of continuity in cases where the contacts were designed for a much heavier current. The material chosen for the heavier load is likely to be unsuited for the lighter one and, while it might be desirable to have one relay for as many different uses as possible, this can not always be done.

Cost Considerations: The least expensive relays in general are the voltage-operated ones, where sufficient power is available to make a fussy adjustment unnecessary. These constitute the "general-purpose" relays. Since contact pressures are high, plenty of contact wipe is obtained, and these relays can be expected to operate well over quite a range of contact current, for example, from 5 to 20 amperes. Outstanding examples of low-cost voltage-operated relays are in home appliances and in automobiles as horn relays and headlamp relays.

As size is reduced, relay costs usually increase, since more accurate parts are needed and coil power is usually less. Adjustment becomes more difficult and the relay becomes less adapted to general purposes.

From a paper entitled "Efficient Application of Relays" presented at the third annual Symposium on Electro-Magnetic Relays at Oklahoma A. & M. College, in Stillwater, Okla., March, 1955.

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We believe that when the users of cylinders sit down across the table from the producer who is trying to make the best, better cylinders result.

We'll be carrying that belief into the Production Engineering Show at Navy Pier in Chicago on September 6. Our College of Cylinder Knowledge booth will be open for that kind of discussion. We'll listen and learn.

The only way we can learn is from you. We can help you. But not until you've dropped that problem of yours in our lap. Your problem contains the stuff of which the better cylinder will be made. The cylinder that will have that quality plus which we like to think is the stamp of Miller Fluid Power.

Remember this when you see the sign over Booth 1819-23. We'll be there to listen to your suggestions, demands and questions. Also, because we are in the cylinder business, we'll be there to show you a cylinder you will want to buy.

Frank Flick

President

MILLER FLUID POWER COMPANY

2006 N. Hawthorne Avenue

Melrose Park Illinois

Visit Miller

BOOTH #1819-1823

Production Engineering

NAVY PIER **SHOW** CHICAGO

The pioneer builder of machine-ground b/b screws announces a revolutionary new line of...

STANDARD-SIZED ROLLED-THREAD SAGINAW Ball/Bearing SCREWS PRICED AS LOW AS, OR LOWER THAN, ORDINARY ACME SCREWS!

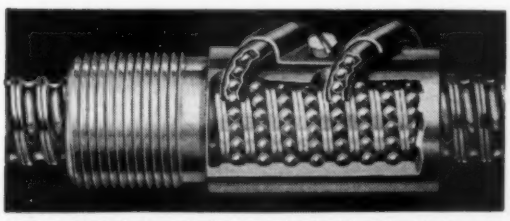
Get up to 6 times more efficiency... save at least 2/3 on power requirements or manual effort!

Here's great news for every manufacturer who uses Acme screws or hydraulic actuators in his product! Saginaw now offers Rolled-Thread *Safety b/b Screws* in standard sizes at amazingly low mass-production cost.

In many applications this new rolled-thread type will provide completely adequate performance at a fraction of the cost of machined-thread units.

GIVE YOUR PRODUCTS THESE PERFORMANCE ADVANTAGES AT NO INCREASE IN COST—

- **At least 90% efficiency guaranteed—compared with 15% to 20% efficiency of Acme screws.**
- **Requires less than 1/3 as much torque as Acme screws for same amount of lineal output.**
- **Saves substantially on cost, size and weight of motors, gear boxes and auxiliary equipment.**
- **Far less wear—less maintenance—longer life.**
- **Precision positioning—free play can be virtually eliminated where necessary.**
- **Operates dependably with or without lubrication at temperatures from −75° F. to +175° F.**



New standard Saginaw ball-nut can be furnished threaded or with flange or trunnion-type adaptors for easy application to almost any unit.

ROLLED-THREAD *SAFETY b/b SCREWS* CAN BE MANUFACTURED IN THESE STD. SIZES AND ANY SCREW LENGTH:

Ball Circle Diameter	Ball Size	Lead
.375	.0625	.125
.631	.125	.200
1.000	.15625	.250
1.171	.28125	.41304
1.500	.34375	.47368
2.250	.375	.500
3.000	.500	.660

ROLLED-THREAD *SAFETY b/b SCREWS* ARE ALREADY BEING SUCCESSFULLY USED IN THESE TYPICAL APPLICATIONS:

- Automatic Garage Doors
- Automobile Seat Adjusters and Window Lifts
- Barber Chairs
- Bumper Jacks
- Circuit Breakers
- Convertible Top Lifts
- Die Table Positioners
- Drill Presses
- Marine Steering Gears
- Welding Machines

Saginaw Steering Gear Division
General Motors Corporation
Dept. 9H, Saginaw, Michigan

Please send detailed data on your new Rolled-Thread *Safety b/b Screws*. I am interested in their application to:

Name—Title_____

Firm_____

Address_____

City_____ Zone_____ State_____

Mail coupon today for full details and engineering recommendations for your needs.

Safety b/b Bearing Screw by Saginaw

Helpful Literature

(*Continued from page 226*)

found in 44-page catalog VR-442. Prices are also given. New items covered include standard blank and rectangular strip sizes; triangular, square and round inserts in "throw-away" lengths; half-length ¾-in. inserts and standard 1½-in. inserts.

35. Telephone Type Relays

Automatic Electric Co.—New uses for telephone type relays in precision control of complicated machine processes are described in 2-page "Relay Highlights No. 4." It describes and diagrams function of rotary stepping switches in controlling two Avey machines.

36. Micrometer Gages

Acme Industrial Co.—Direct reading chamfer micrometer gages are subject of descriptive 4-page bulletin PD59-29. Model 90 will read end diameters of chamfers up to 1 in. from 0 to 90-degree chamfer, while model 127 will indicate chamfers up to 1 in. from 90 to 127-degree chamfer.

37. Self-Locking Nuts

National Machine Products Co. — Huglock nuts which maintain their locking action through repeated removals are subject of 24-page illustrated catalog. Prices, dimensions and application data are given on these fasteners which range in size up to 1 in. and are available in several styles.

38. Molybdenum Lubricant

Alpha Corp. — Comparison tests between Molykote type G concentrated molybdenum disulfide paste lubricant and other thread lubricants at room and elevated temperatures are detailed in 2-page Field Report 141. Lubricant is made for highly loaded threaded connections.

39. High Pressure Equipment

High Pressure Equipment Co.—24-page catalog 2055 provides detailed listing of high pressure valves, fittings and tubing. Specifications also cover HIP midget valves and fittings as well as Taper Seal stainless valves and fitting for pressures to 6000 psi. Standard connections are designed for pressures up to 60,000 psi.

40. Flexible Exhaust Hose

Flexaust Co.—Set of five bulletins (Nos. 40 through 44) and price lists will be of interest to anyone concerned with design, installation or purchase of flexible hose used in dust and fume control, air conditioning and materials handling. Data cover accessories, installation, application and friction loss.

41. Plastic Materials & Fabrications

American Agile Corp.—48-page illustrated general catalog describes a complete line of polyethylene and polyvinyl chloride fabricated products, plates, sheets, rods, tubes, pipes and fittings. Also covered is hot gas welding and spraying equipment for use in fabricating these and other plastics.

42. Rod End Bearings

Southwest Products Co.—4-page illustrated bulletin 2155 gives dimensions and load ratings of SCREF and SCREM female and male rod end bearings. Patterned after the existing Monoball bearings, this new line includes bore sizes from $\frac{1}{8}$ to ¾-in.

43. Coolant Filters

Industrial Filtration Co.—Delpark full-flow, self-cleaning, continuous and fully automatic coolant filters for use on precision grinding machines are subject of 4-page bulletin. It illustrates models for use with Cincinnati No. 2, 3 and 5 centerless grinders and Cincinnati chucking grinder.

44. Variable Speed Drive

Gerotor May Corp.—Details of the new Gerotor variable speed hydraulic transmission are given in 4-page illustrated catalog section T-100. This drive provides infinitely variable speeds up to 1500 rpm, constant or variable torque and horsepower, smooth braking and reversing either instantaneous or delayed, full range of controls from hand to automatic and positive overload protection. Model B is rated 3½ hp.

45. Automation

M. W. Kellogg Co.—Automation in the petroleum and chemical industries is subject of 1955 issue No. 3 of the "Kelloggram." Diagrams are used to show basic functions of instruments used in automtic control. Use of radioisotopes in level measuring devices, data reduction systems, electronic instrumentation, stream analyzers and high pressure instruments are topics covered.

46. Heavy Equipment Filters

Marvel Engineering Co.—Synclinal filters, available in sump and line types in capacities from 5 to 100 gpm, are illustrated in this data sheet. Wide variety of applications in heavy equipment are shown. Monel mesh sizes range from 30 to 200.

47. Small Motors

Barber-Colman Co. — Barcol double-plate open-type geared motors with starting torques up to 75 lb-in. are described in 4-page illustrated bulletin F-6841. Unidirectional synchronous and nonsynchronous, and reversible nonsynchronous types have gear ratios from 4:1 to 30,000:1, heavy duty gears and output shafts, and long-life lubrication.

48. Pilot Relief Valves

Fluid Controls, Inc.—Five catalog sheets 1.211, 1.221, 1.222, 1.231 and 1.251 contain design and performance data on ¼, ⅜, ½, ¾ and 1-in. pilot relief valves for use on machinery, machine tools and other equipment using hydraulic power.

49. Panel Instruments

DeJUR-Amsco Corp.—Model 131 ruggedized 1½-in. panel instruments are described and illustrated in 2-page data sheet. Instruments are designed for size and weight reduction in electronic equipment subject to shock, vibration or temperature extremes. They have water-tight seal, D'Arsonval movement and high flux density magnets.

50. High Temperature Cables

General Electric Co.—Silicone rubber-insulated high-temperature wires and cables are subject of descriptive booklet 19-594. Listings and specifications are provided on power cable, control cable, appliance and fixture wires, apparatus leads, heating cable, defroster wire, aircraft wire, shipboard cable and generator leads.

51. Special Conveyor Belts

B. F. Goodrich Co., Industrial Products Div.—Special conveyor belt constructions are described in data sheet 2255. Featured is Riffle Grip conveyor designed to retain or separate water content from load during belt travel on inclined conveyors. Sheet also describes wire-inserted belts for foundry service.

52. Brass Rod Mill Products

Titan Metal Mfg. Co.—20-page pocket-size booklet "For Your Metal Money's Worth" describes all Titan brass rod mill products. Weight tables, specifications and other technical data are listed on free-cutting brass, commercial bronze, Ti-nic-o-sil, Tombasil, forging rods and shapes, brass wire and Tru Shaft boat shafting.

53. Solenoid Valves

Valcor Engineering Corp.—Developed for industries where sanitation and high performance are important, the SV-2700 series of solenoid valves are subject of descriptive 4-page catalog 101. Series features built-in stainless tubing connection fittings and includes types with plastic see-through body. Valves are designed for pressures of 125 psi.

54. High Temperature Alloy

Allegheny Ludlum Steel Corp.—Performance data on superalloy A-286 is furnished in 4-page technical data folder. Metal is a corrosion and heat-resistant austenitic alloy which has high strength at up to 1300° F. Application information, physical and mechanical properties and heat treating information are included.

55. High Wattage Rheostats

Hardwick, Hindle, Inc.—Use of high temperature enamel, bus bar construction, constant-pressure contact arm and tripod mounting frame are features of five high wattage rheostats described and illustrated in 4-page bulletin. Ratings are 225, 300, 500, 750 and 1000 w. Specifications are given for all models.

56. Air Line Lubricator

Gits Bros. Mfg. Co.—One size of Gits Airliner air line lubricator will handle any air line up to ½-in. size. Oil is atomized in a remote chamber, and only oil mist is metered into the air stream. Subject of 4-page illustrated bulletin, device can lubricate any amount of air from ¾-cu ft to capacity of air line.

57. Flexible Metal Hose

Atlantic Metal Hose Co.—Applications for the 12 types of interlocking flexible metal hose described in bulletin 50-B include exhausting gases and fumes from cars, trucks and motor test rooms; industrial dusters and dust spraying equipment; conveying grindings and other light solids; and as wire casing for prestressed concrete. Detailed specifying data are given.

58. Thermostat Metal

Metals & Controls Corp., General Plate Div. —Manufacture of Truflex thermostat metal is outlined in catalog which also presents data on selection of thermal elements and their design. Tables give major mechanical and physical constants for 40 different types of metals.

59. Titanium Alloy

Mallory-Sharon Titanium Corp.—Metallurgy and chemistry of MST 6A1-4V titanium alloy, its properties and recommended heat treatment, forging and welding procedures are listed in 4-page bulletin. Alloy overcomes problem of high temperature embrittlement and can be used at up to 750° F with minimum creep or change of properties.

60. Investment Castings

Precision Metalsmiths, Inc.—"Pour Yourself an Assembly" is title of 12-page brochure which gives a step-by-step picture of the Precision investment casting process. It describes company's counseling service and pictures such procedures as the initial waxing, assembly and set-up, and making the investment mold.

61. Electric Motor

U. S. Electrical Motors Inc.—Cut-away views of the type H Uniclosed motor show construction features in 12-page booklet. Ventrifoil at both air intakes of motor protects the interior. End brackets prevent entrance of water and dust, yet allow air flow. Motor conforms to NEMA specifications and is available in various sizes.

62. Die Springs

Danly Machine Specialties, Inc.—14-page illustrated "Die Spring" catalog and accompanying net price list gives specifying information on a complete line of die springs, including medium, medium-high and high pressure types. Tables aid in selecting the correct size and capacity of spring for each specific operation.

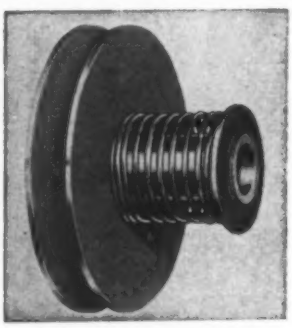
NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 225

Pulley 63

adjustable-speed unit has 2¾:1 speed ratio

This ¾-hp variable-pitch pulley is adjustable for speed ratios up to 2¾:1, using an A-section V-belt. Maximum bore is ⅞-in. with a keyway. The shaft bore runs through the entire length of the pulley, permitting reverse mounting when necessary. Oil-impregnated bronze bearings and simple design mini-



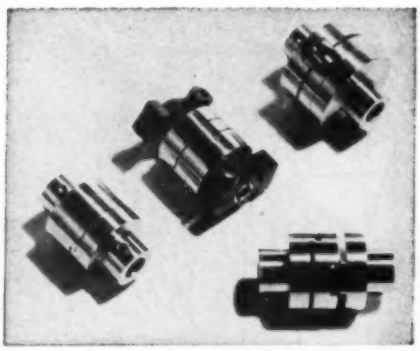
mize maintenance. Pulley measures 4 13/16 in. long and 6 in. in diameter. Made by **Lovejoy Flexible Coupling Co.**, 4818 W. Lake St., Chicago 44, Ill.

Circle 63, Page 225, for more data

Miniature Couplings 64

are made for pin or clamp type hubs

Type T3 precision miniature Oldham coupling consists of two identical male coupling parts, each of which is precision machined with pin hub or split clamp type hub as required, plus a single female floating coupling element. Perpendicular slots in the floating element secure this part between the



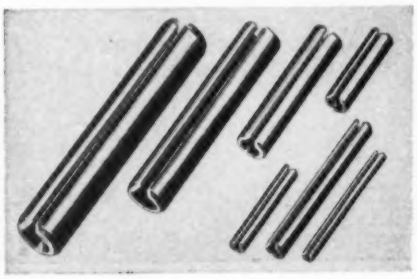
two male parts without fasteners. The coupling compensates for lateral and slight angular misalignment of shafts. It will handle heavy loads and operates at speeds up to 2500 rpm. Clutches are stainless steel, passivated throughout. Measuring ¾-in. in diameter, they are designed for basic shaft sizes of ⅛, 3/16 and ¼-in. Clamps for clamp type hub are available. Made by **PIC Design Corp.**, 160 Atlantic Ave., Lynbrook, L. I., N. Y.

Circle 64, Page 225, for more data

Pin Fastener 65

conducts electricity and resists corrosion

Beryllium copper Rollpin, a slotted, chamfered tubular spring pin, has nonmagnetic qualities, good electrical conductivity and high corrosion resistance. It is particularly

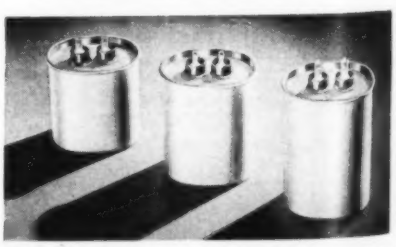


useful in conjunction with other copper-base alloy components where galvanic action is an important design consideration. The pin functions as a taper pin, straight solid pin and setscrew, as well as a rivet, dowel hinge pin, cotter pin or stop pin. Insertion into a hole slightly smaller than the pin compresses the pin and produces continuous spring pressure against the hole walls. This pressure prevents loosening even under severe vibration. Pin is heat-treated for high strength. Sizes range from 0.062 to 0.250-in. diameter, in a wide range of lengths. Made by **Elastic Stop Nut Corp. of America**, 2330 Vauxhall Rd., Union, N. J.

Circle 65, Page 225, for more data

AC Capacitors 66

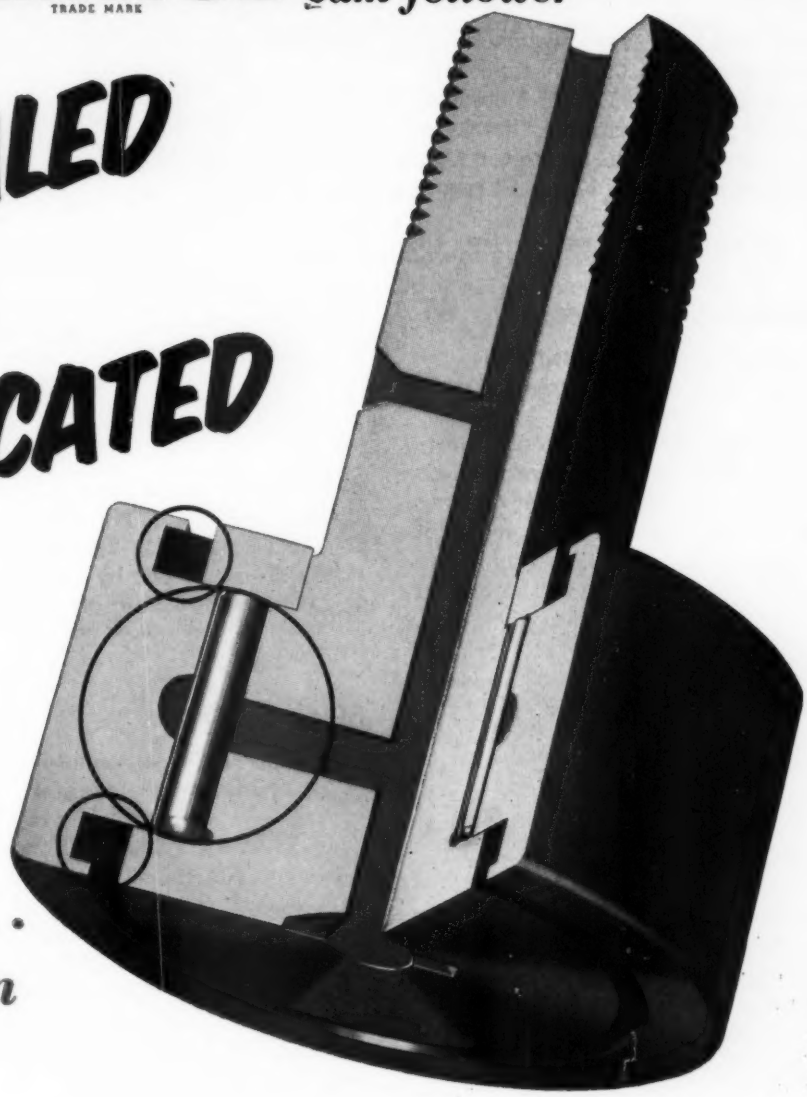
offer three types of terminal connections



These drawn oval capacitors are available for 236, 330 and 440-v. 60-cycle, ac operation. All sizes are housed in cases with seamless sides, the tops being joined to the cases by means of strong, double-rolled seams. Cases are filled with chlorinated diphenol resin, which is nonflammable, has high dielectric qualities and remains stable even at high operating temperatures. Three types of terminals are available for either mechanically joined or soldered leads. Quick-connect

the NEW McGILL® **CAMROL** TRADE MARK *cam follower*

NOW SEALED and PRELUBRICATED



to eliminate contamination . . . save re-lubrication

McGILL®
SCF series
CAMROL TRADE MARK
bearings

Write for your copy today

In one simple assembly, the Sealed CAMROL cam follower bearing gives you three big advantages: 1. capacity to withstand the shock and load of cam action, 2. sealing against contamination that would impair the life of an unprotected bearing, 3. prelubrication that saves frequent relubrication so often undesirable in cam action application. Specially traeated seals are built in at stud and flange ends, and a black oxide finish offers outside corrosion resistance. A channeled reservoir in the outer raceway bore helps store reserve lubrication sufficient in many cases for lifetime service. The new SCF series bearings do not add to the size or weight of standard CAMROL cam followers and are dimensionally interchangeable with them. Ask your McGill representative to show you this newest McGill contribution to the superior performance of your cam actioned machinery, or write to our engineering department for recommendations. Send for Bulletin SCF-55 for more detailed information.

50th McGILL Anniversary

Insure performance with McGILL®. . .

MULTIROL®—GUIDEROL®—**CAMROL** *full type roller bearings*

McGILL MANUFACTURING COMPANY, 200 N. Lafayette Street, Valparaiso, Indiana

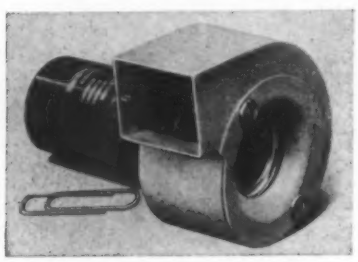
eyelet and fork types are made for conventional or barrier type terminal mounting. Either footed or wrap-around mounting brackets are offered. Made by **Potter Co.**, 1950 Sheridan Rd., North Chicago, Ill.

Circle 66, Page 225, for more data

Subminiature Blower 67

operates at high altitudes and high temperatures

This high-velocity centrifugal blower is 2⅞ in. long and weighs less than 6 oz. Designed for cooling air-borne electronic equipment, it meets MIL specifications. The blower is available for rotation in



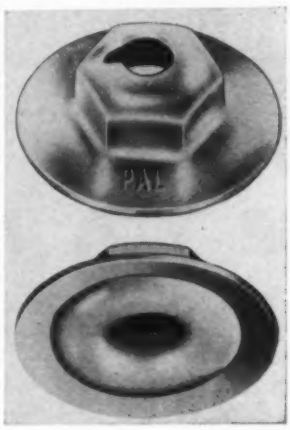
either direction in single and double-end models. Metal housing can be rotated to any required position. Free air delivery of the single-end model is 13 cfm at 20,000 rpm and 7 cfm at 11,000 rpm. Velocity at 20,000 rpm is 3000 fpm. Motor is available for single or three-phase alternating current. Made by **Eastern Air Devices Inc.**, 385 Central Ave., Dover, N. H.

Circle 67, Page 225, for more data

Locknut 68

seals out water and dust

The addition of a sealing compound to these washer type locknuts provides a complete seal around threads and nut seat when the nut is tightened, preventing entrance of water, dirt and dust. This sealer type locknut functions as nut, lock washer, flat washer and sealing washer. Rapid assembly is achieved with standard power tools. The resilient spring steel construction reduces damage to studs, screws and fastened parts and cushions the shock of power drivers. Spring locking force is exerted inward on the threads and downward on the base to prevent loosening under vibration. Nuts are available in No. 8-32, 10-24, 12-24 and ¼-in.-20 sizes. Made by **Palnut Co.**, 61 Cordier St., Irvington 11, N. J.

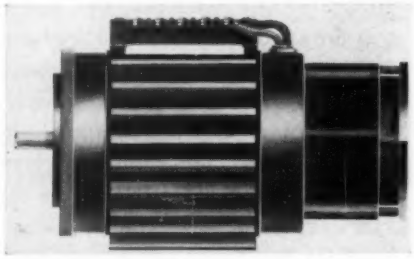


Circle 68, Page 225, for more data

Motor-Generator 69

combines 35-w servomotor with tachometer generator

This 35-w, two-phase, 60-cycle ac servomotor-tachometer generator can be used to regulate speed of a motor or to stabilize closed-loop circuits. Mounting of the motor and tachometer on one shaft results in zero backlash. The motor component is rated for continuous duty at rated output. It can be stalled continuously with one phase of the motor excited at rated voltage and frequency. The tachometer generator can be excited with its rated voltage and frequency. Suitable for use in automatic controllers, the tachometer can be adjusted easily after installation so that in-phase residual voltage can be kept at essentially zero. For magnetic amplifier application, 57½/57½-v control-phase windings are available. Minimum locked torque of the motor is 45 oz-in. Output of the tachometer is 6 v per 1000 rpm. Linearity is 1.0 per cent at 3000 rpm. Made by **Diehl Mfg. Co.**, Servomotor Dept., Finderne Plant, Somerville, N. J.

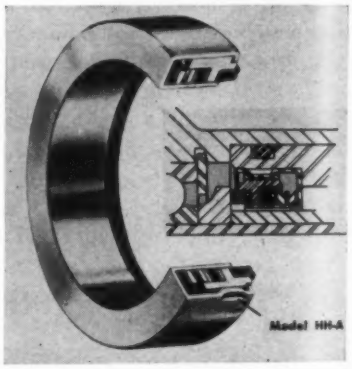


Circle 69, Page 225, for more data

Shaft Seals 70

are of compact design

Effective shaft sealing in minimum radial and axial space is provided by type HH rotary shaft seals. They operate under extreme conditions of temperature, pressure and seal face surface speed. Types are offered for external and internal fluid pressure applications.



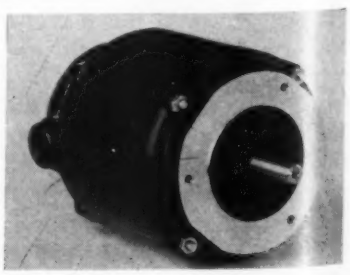
Photograph and cross-sectional drawing show pressure balance when external fluid pressure is applied. Stock sizes are available for nominal shaft diameters from ¼ to 2 in. in increments of 1/16-in.; from 2⅛ to 3 in. in increments of ⅛-in.; and for 3¼, 3½, 3¾ and 4 in. shafts. Made by **Gits Bros. Mfg. Co.**, 1833 S. Kilbourn Ave., Chicago 23, Ill.

Circle 70, Page 225, for more data

Low-Speed Motors 71

are available for 75 or 100-rpm operation

Two synchronous inductor motors, which are self-starting and reversible without gears, are available in NEMA 20 and 54-frame sizes. Both motors accelerate to synchronous

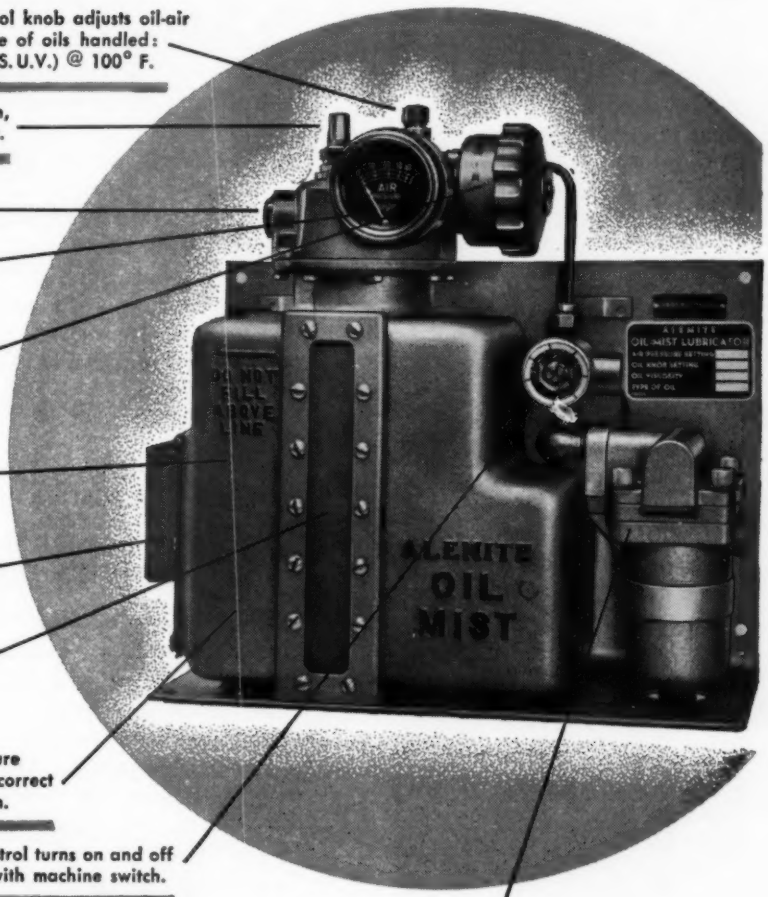


You asked for it! Designers told us what industry had to have!

ALEMITE OIL-MIST

Proved in countless applications—multiplies bearing life—slashes product spoilage—boosts machine output!

Hundreds of case histories prove savings, ease of installation, increased output with Oil-Mist. And Oil-Mist is simple to design into any machine. Oil-Mist applies a constant, clean, cool film of oil uniformly to working parts — vees, chains, slides, gears, all types of bearings. Replaces grease systems. No moving parts — operates on compressed air — completely automatic, fool-proof!



1. Oil flow control knob adjusts oil-air mixture. Range of oils handled: to 1,000 sec. (S.U.V.) @ 100° F.
2. Loader fitting for fast, clean, filtered refilling of reservoir.
3. Oil-Mist delivery outlet for main line leading to bearings.
4. Air gauge registers to 50 psi.
5. Air regulator—operating pressure 5 to 20 psi. Reduces pressures from up to 200 psi. Normal air consumption, .7 to 1.2 cfm.
6. Reservoir capacity one gallon. Also available in 12 oz. size.
7. Low level indicator switch turns on warning signal or stops the machine when oil level is low.
8. Nylon plastic window gives visible check of oil supply.
9. Heater for outdoor or low temperature applications. Thermostat keeps oil at correct temperature for efficient atomization.
10. Solenoid air control turns on and off simultaneously with machine switch.
11. Moisture separator and filter removes up to 98% of moisture from incoming air at flow rate up to 1 cfm.

Complete range of models and multiple unit models to fit any machine—any application

Three types of bearing fittings allow the use of OIL-MIST on any machine!

Oil-Mist fittings bring the most efficient lubrication in the world to any anti-friction bearing—roller, ball, needle.

Spray fittings are recommended for open and enclosed gears and chains. Allow for a concentrated spray of oil where needed.

Condensing fittings apply oil in liquid form to plain bearings, slides, ways, vees, cams and rollers.

Alemite Oil-Mist offers these lubrication advantages

Automatic lubrication • Continuous lubrication
Eliminates guesswork • Greater safety • Cuts oil consumption up to 90%
Extends bearing life • Stops oil drippage • Saves man-power
Reduces number of lubricants needed • Eliminates "Down-time"

FREE...write today!

Use coupon below for your free copy of the Oil-Mist catalog and data book!

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City ..... State .....

ALEMITE OIL-MIST LUBRICATION

A PRODUCT OF SW STEWART WARNER

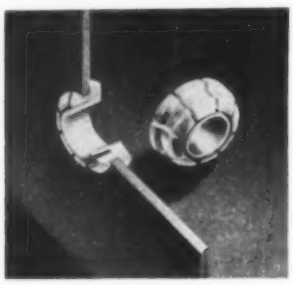
speed in ½-cycle or less, and the permanent magnet rotor stops within 7 deg with moderate external inertia. The 54-frame motor, with a torque rating of 75 oz-in., operates at 75 rpm on 60, 50 or 25-cycle, 115 or 230-v current. Torque rating of the 20-frame motor is 2 oz-in., operating at 100 rpm on 60-cycle, 115-v current. Correspondingly lower speeds are produced at 50 and 25 cycles. Both motors are of three-lead design, reversible by a single-pole, double-throw switch. They start, stop, and reverse rapidly and will withstand stalling without overheating. Made by **General Electric Co.**, Specialty Component Motor Dept., Schenectady 5, N. Y.

Circle 71, Page 225, for more data

Teflon Grommets 72

resist chemical action and heat

Nonabrasive S11154 one-piece Teflon grommets are designed to guide and support cables and conduit through bulkheads and sheet metal enclosures. They withstand temperatures from −110 to 350 F and are resistant to chemical action. They are easily installed



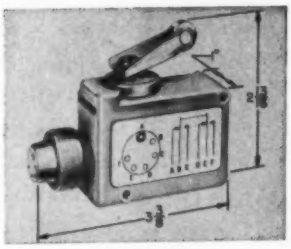
from one side and are available in full range of diameters for 0.025 to 0.125-in. thick sheet. Made by **Shamban Engineering Co.**, 11617 W. Jefferson Blvd., Culver City, Calif.

Circle 72, Page 225, for more data

Sealed Limit Switches 73

withstand severe environments

Line of EP sealed limit switches is designed for use in aircraft, mobile, marine and industrial applications where environmental conditions are severe. In addition to being sealed, switches contain an



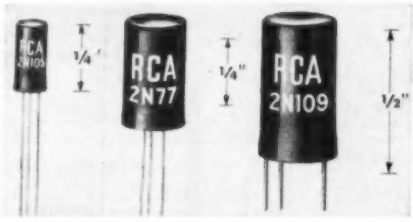
inert gas which prevents their operation from being affected by atmospheric changes or environmental shocks. They are offered in either side or bottom-mounting designs and conform to MIL-S-6744 vibration and shock-resistance tests, as well as immersion test specifications MIL-E-5727A. Contact arrangement is two-circuit double-break for controlling two isolated circuits. Switches are rated 1 to 15 amp, depending on voltage and type of load. Made by **Minneapolis-Honeywell Regulator Co.**, Micro Switch Div., Freeport, Ill.

Circle 73, Page 225, for more data

Junction Transistors 74

for either low-power or large-signal audio applications

These three alloy-junction transistors are of the germanium p-n-p type. They are hermetically sealed and utilize insulated metal envelopes. Models designated 2N105, shown at left, and 2N77, center, are designed for low-power, audio-frequency amplifier service. They have flexible leads. Low base-lead resistance minimizes ohmic losses, provides good frequency response, and insures high input-circuit efficiency. In a common-emitter circuit they have collector-to-base-connection current



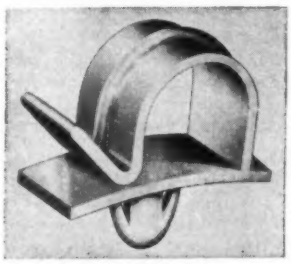
amplification ratio of 55. The collector dissipation can be as high as 35 mw. Type 2N109 is designed for use in large-signal applications such as class B audio service and as a high-gain class A driver device. It has a linotetrar three-pin base. In a common-emitter circuit, this transistor has a large-signal base-connection-to-collector dc-current amplification ratio of 70. The collector dissipation can be as high as 50 mw. Made by **Radio Corp. of America**, Tube Div., Harrison, N. J.

Circle 74, Page 225, for more data

Plastic Clamp 75

withstands a wide range of temperatures

This one-piece nylon fastener is nonchafing and noncorrosive. It is lightweight and self-insulating and withstands a wide temperature range. The curved base of the clamp and the snap-in method of attachment provide a tight, vibration-free application. Various wire and tube sizes and panel thick-



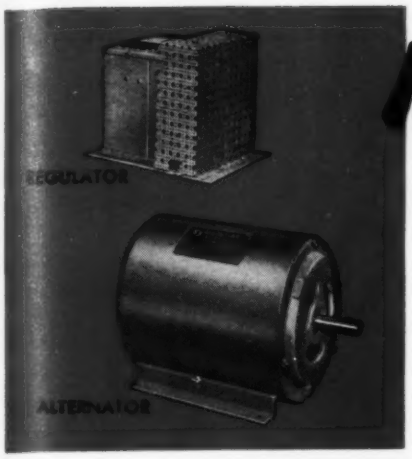
nesses can be accommodated. Made by **Illinois Tool Works**, Shakeproof Div., 2501 N. Keeler Ave., Chicago 39, Ill.

Circle 75, Page 225, for more data

Clutch Controls 76

operate at high speed on presses with pneumatic clutch and brake

Made in three sizes, these high-speed clutch controls provide non-repeat protection and the functions of inching, single stroke and continuous operation. Selection is controlled by the positioning of an exterior oil-tight selector switch. The small, basic control meets average requirements of a high-speed press. The medium size control can be equipped for timed-inching or with a Size 1 magnetic motor starter. The large size, built to conform to JIC and NMTBA standards, incorporates controls for press clutch and brake, Size 1 starter for press drive motor, and ex-



Now...TAKE AC POWER ANYWHERE A VEHICLE CAN GO!

MO-BIL-AC* (mobile a-c power supply) driven by vehicle engine, supplies up to 10 KW at 110-220 volts . . . .

takes little space

Designed by Star-Kimble to meet the need for a compact, portable source of AC at commercial voltage and frequency, MO-BIL-AC drives a-c powered tools, pumps, compressors, hoists and similar equipment in the field . . . *wherever a self-propelled vehicle can go.*

An outstanding feature of MO-BIL-AC is its low size-weight to power output ratio. To achieve it, a 2-pole alternator is excited by a compact, lightweight regulator with a selenium rectifier and magnetic amplifier working off the alternator output.

This unique S-K development also insures excellent transient response: upon application of full load, voltage recovers in one second or less. Speed of prime mover is not critical because regulator keeps output voltage proportional to output frequency. Thus, standard motors may be operated over a wide frequency range without overheating.

MO-BIL-AC is available in 3, 5 and 10 KW ratings, 60 cps, single and polyphase, any commercial voltage.

Write or phone for full descriptive literature.

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Star-Kimble MOTOR DIVISION

MIEHLE PRINTING PRESS & MFG. CO.

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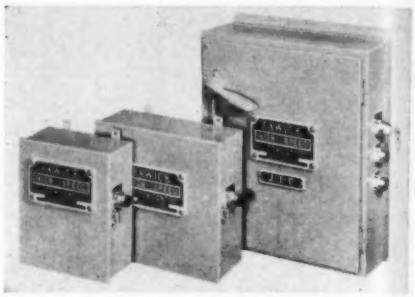
BLoomfield 2-8160

New Parts



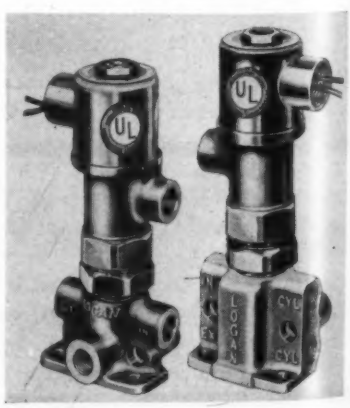
ternally operated, cover-interlocked disconnect switch. Hand-foot, semicontinuous and timed-inching are all optionally available. The enclosures are of NEMA 12 construction with gasketed cover and external mounting straps. Primary transformers for voltages of 220 and 440 v are provided. The air solenoid operates on 110 v ac from the transformer. The miniature, fast-operating relays are controlled from a rectified 90-v dc circuit. Made by **Fawick Corp.**, Fawick Airflex Div., 9919 Clinton Rd., Cleveland 11, O.

Circle 76, Page 225, for more data

Air Control Valves 77

can be controlled by pushbutton, limit switch or timer

Three new valves can be controlled by such means as electric push-button, limit switch or timer. Model 6668 is a solenoid bleeder, air cylinder-actuated valve for control of bleeder and pilot-operated master valves. Removal of a plug in the lower, or center, port converts the valve from two to three-way operation. Standard coils are varnish-impregnated for 115 or 230-v, 50 or 60-cycle continuous duty ac operation. Other coils are available. The valve is designed for side or base mounting. Design of model



New Parts

6669 dual-control, two-way valve is the same as model 6668 except for two exhaust openings which permit bleeding both ends of the master valve alternately. Reversal is automatic when electric current to the solenoid is shut off. Four-way, two-position model 6678 is designed for operating double-acting air cylinders. Maintained contact of the control switch is required to direct air flow out of the lower cylinder port. In other respects, this valve is also the same as model 6668. Made by **Logansport Machine Co.**, Logansport, Ind.

Circle 77, Page 225, for more data

Gearless Differential 78

uses precision balls for minimum backlash

Designed for applications requiring minimum backlash, model T751 differential employs tungsten carbide balls. The balls and plate upon

which they ride are lapped to assure accuracy. Differential is installed in a servo type case. Both input gears are accessible through slots in the side of the case. Made by **Sterling Precision Instrument Corp.**, Instrument Div., 34-17 Lawrence St., Flushing 54, N. Y.

Circle 78, Page 225, for more data

Nylon Tubular Bars 79

are centrifugally cast and accurately bored

Accurately turned and concentrically bored nylon tubular bars are available for fabricating such parts as bearings, thrust washers, wheels, gears and seals. Parts made from the centrifugally cast, heavy-walled tubing offer excellent wear and frictional properties, toughness, heat resistance, chemical resistance and damping characteristics. Cast to approximate size,

NEW Versatile G-E Timer Designed for Your Timing Job

General Electric's new TSA-18 timer will reduce your industrial timing costs by eliminating the need for additional expensive features in your timing equipment. The extreme versatility offered by this new timer enables it to meet, with precise and dependable operation, the majority of your timing-equipment requirements.

Here are a few of the outstanding features of the new TSA-18 which will meet your specific timing application requirements at no extra cost:

(1) **DELAYED ON AND OFF TIMING** in time ranges from 10 seconds to 30 hours is available within the seventy different TSA-18 models.

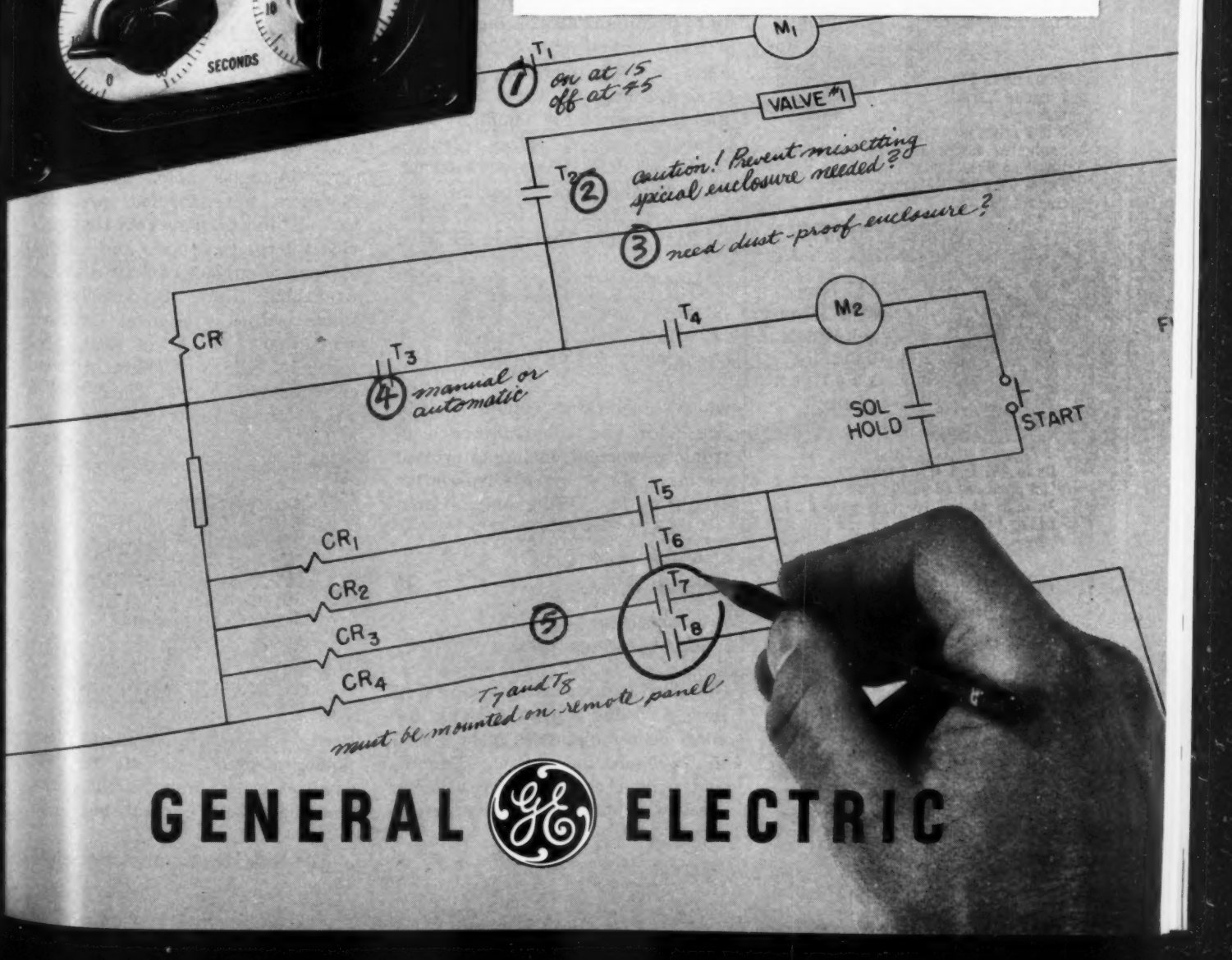
(2) **TO PREVENT MISSETTING,** each TSA-18 timer is equipped with a knob locking device.

(3) **DUSTPROOF ENCLOSURE**—standard equipment on all TSA-18 timers.

(4) **MANUAL AND AUTOMATIC CONTROL**—standard on all units—is available to you at no extra cost.

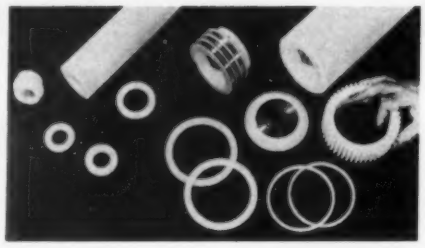
(5) **FOR MULTIPLE CIRCUIT CONTROL** the TSA-18 can be cascaded without interfering with the proper location of the timing controls.

For more information call your nearest General Electric Apparatus Sales Office, or write for Bulletin GEC-1223 to Section 584-1, General Electric Co., Schenectady 5, N. Y.



GENERAL ELECTRIC

New Parts and Materials



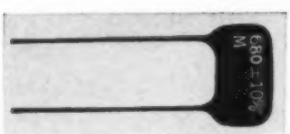
the tubular bars are annealed and machined to close dimensional tolerances. Size range of the stock is similar to that generally available in brass and bronze. Outside diameters range from 2 to 10 in., with wall thicknesses of ⅜ to 1 in. Standard lengths are 8 and 13 in. Made by **Polymer Corp. of Pennsylvania,** 126 N. Fifth St., Reading, Pa.

Circle 79, Page 225, for more data

Mica Capacitors 80

miniature units are stable at high temperatures

Dur-Mica DM-20 dipped mica capacitors are available in capacities up to 5100 mmf at working voltage of 300 v dc and up to 3900 mmf at 500 v dc with operating temperatures up to 125 C. They have parallel leads and meet humidity, temperature and electrical requirements of MIL-C-5 specifications. The phenolic-coated capacitors are ¾-in. long, 7/16-in. wide and 3/16-in. thick. They have parallel leads



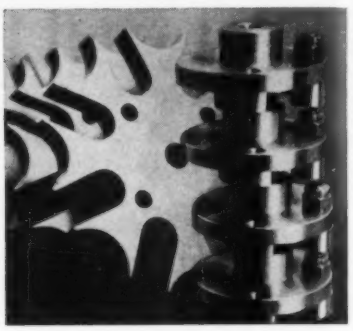
which facilitate application in transistor and subminiature electronic equipment, including printed circuits. Made by **Electro-Motive Mfg. Co. Inc.,** Willimantic, Conn.

Circle 80, Page 225, for more data

Geneva Drives 81

balanced for high-speed operation

Standard geneva drives are offered in 4, 5, 6 and 8-point designs, for shaft center distances from 3 to 6 in. in ⅛-in. increments. Driving and driven elements are crucible steel with provision for accurate balancing for high-speed operation. The angle of escapement is so designed that the wheel cannot start indexing until the pin completely enters the slot. Degree of angle



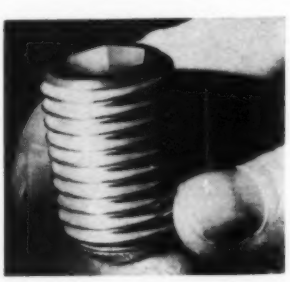
depends on both center distance and wheel diameter. Bolt holes in the wheel permit mounting to a gear sprocket or pulley, and a driver hub of any length and diameter can be furnished. Made by **Genevamatic Engineering Corp.,** 402 Ellamae Ave., Tampa, Fla.

Circle 81, Page 225, for more data

Setscrews 82

withstand high torque in tightening

High-torque Unbrako setscrews exhibit great holding power and uniform fit of key in socket and of screw in tapped hole. These steel fasteners have formed, precision threads and deep sockets that provide a large wear area and a large amount of surface contact with the wrenching key. Stress-relieving fillets at the socket corners strengthen the socket wall, permitting tight wrenching without cracking the screw. Hard socket walls prevent reaming of the socket by the key even under high recommended tightening torques. A



hard, self-locking knurled cup point, available on all but the smallest sizes, prevents the screw from loosening once it has been

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Only one size needed to handle any air line up to ½" pipe size.	■			
Only oil MIST metered into air stream.	■			■
Can be filled and serviced without air line shut-down.	■	■	■	
Can lubricate any amount of air—from ¾ cu. ft. up to capacity of air line (½" or less).	■			
Tamper-proof adjustment.	■		■	
CONSTANT lubrication, resulting in minimum waste and contamination.	■			■
In-line mounting.	■	■	■	■
Operation is monitored instantly, clearly, easily.	■			
Maintains minimum pressure drop, regardless of air volume and pressure.	■			
Filtered oil feed tube.	■		■	
Absolute lubrication, regardless of cycle frequency.	■			■
Adaptable to right- or left-hand mounting without modification.	■			
Instant starting.	■			■
Visible oil reservoir.	■	■	■	■

more than 100% greater efficiency
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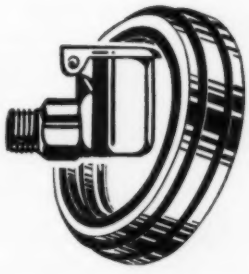


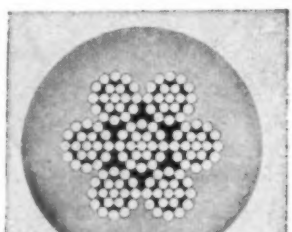
tightened. Tolerances are held to as close as 0.0005-in. between socket and mating key. The line includes the knurled cup, as well as plain cup, oval, flat, cone and half-dog setscrews in 18 sizes from No. 0 to 1 in. in diameter. Made by **Standard Pressed Steel Co.**, Jenkintown, Pa.

Circle 82, Page 225, for more data

Wire Rope 83

has flexible plastic coating

This new cable is made of either preformed galvanized steel or stainless steel wire rope coated with strong, flexible plastic. The coating resists sunlight and oxidation and is also resistant to most acids, bases, salts, oils and greases, except hydrofluoric acid and methyl ethyl ketone. Strength of the rope ranges from 480 to 7000 lb. The coating is available in



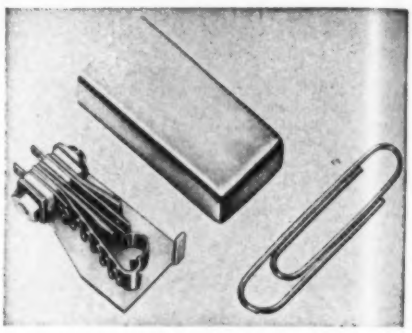
transparent green or opaque white. Color stability is excellent. Size of rope ranges from 1/16 to ¼-in. before coating; after coating corresponding sizes are ⅛ to ⅜-in. Made by **MacWhyte Co.**, Kenosha, Wis.

Circle 83, Page 225, for more data

Overload Switch 84

is designed for fractional-horsepower motors

All-metal, fractional-horsepower, motor thermal overload switch provides positive protection against overload current as well as frame overheating. Mounted on the motor frame, it picks up heat by conduction and thus is sensitive to frame temperatures. Metal case provides complete shielding against RF interference. Voltage drop is slight because the heating element has low resistance. Bimetallic heater operates contacts by snap action. The thermal cutout is factory set for 225 to 325 F and operates independently of heater current. Units are self-resetting. Maximum rating for the switch is 30 v dc, 10



amp; or 115 v ac, 5 amp. Minimum opening time is 15 seconds. Contacts are fine silver; spring elements are beryllium copper. Case measures 1 5/32 x 17/32 x 11/32-in. An uncased switch can be mounted inside a motor. Made by **Nader Mfg. Co.**, 2661 Myrtle Ave., Monrovia, Calif.

Circle 84, Page 225, for more data

Radio Noise Filter 85

occupies approximately ½-cu in. of space

Lightweight, dual Pi noise filter for actuator motors consists of four 0.5-mfd capacitors and two 0.5-mh toroids. Rating is 2 amp at 200 v dc. The filter measures ⅞ x ⅞ x 9/16-in. and weighs

⅞-oz. Efficiency is such that noise level is brought far below MIL-I-6181 requirements throughout the frequency spectrum. Epoxy resin dielectric permits efficient operation at 300 F. Compression glass-to-metal hermetic seals are incor-

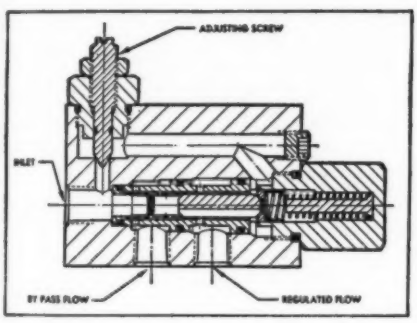
porated. The filter mounts on the top or side of the motor case. Mounting plate is made to specific requirements. Made by **Electronic Specialty Co.,** Miniature Components Div., 5121 San Fernando Rd., Los Angeles 39, Calif.

Circle 85, Page 225, for more data

Flow Regulators 86

combination by-pass and restrictor type is adjustable

These adjustable pressure-compensated flow regulators, made in ⅜ and ¼-in. sizes, maintain constant regulated flow when pump output varies or is greater than required for part or all of the system. The



regulator provides additional flow from the by-pass port that can be used for operating other parts of the hydraulic system. Flow can be regulated from ½ to 7½ gpm and will not vary more than ±5 per cent as long as fluid specifications are not materially changed. Regulators can be connected in series to provide additional regulated circuits from one pump or power source. Made by **Fluid Controls Inc.,** 1284 N. Center St., Mentor, O.

Circle 86, Page 225, for more data

Miniature Read-Outs 87

provide output display

These miniature digital in-line read-outs consist of engraved lucite plates held in a precision-milled holder. The numbers, which are less than ½-in. high, are individually illuminated by miniature, aircraft type bulbs. Design reduces cross-lighting effects and provides clear readings. Speed of response is limited only by the response of the bulbs. Overall height of the read-out units is 1¾

in.; depth is 1¼ in. They are available in any number of decades and with special symbols as well as worded displays. Made by **Electro Instruments Inc.,** 3794 Rosecrans St., San Diego 10, Calif.

Circle 87, Page 225, for more data

Solenoid Valves 88

are electrically inoperative when cover is removed

These three and four-way Pilot-Master valves are now available with solenoid valve heads which meet JIC electrical recommendations that air cylinder control valves be electrically inoperative when a solenoid cover is removed. Die-cast zinc alloy covers are splashproof and dust-tight and are

held in place by four captive screws. At the end of each cover is an O-ring sealed button which can be operated with a small screwdriver without removing the cover. Covers are available for series B three-way and series BB four-way valves in sizes from ⅜ to 1¼ in. IPS. Both single and double sole-

New Parts

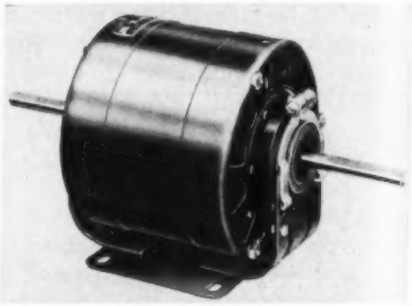
noid (momentary contact) models are available in both series. Made by **Hannifin Corp.**, 516 S. Wolf Rd., Des Plaines, Ill.

Circle 88, Page 225, for more data

Split-Capacitor Motors 89

available in ratings to ¼-hp

Line of permanent split capacitor motors is made with heavy pressed steel cases, self-aligning bearings having design characteristics of sleeve bearings, and balanced die-cast rotors. Double varnish impregnated components with



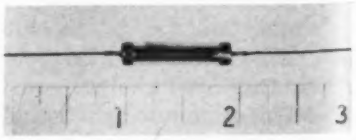
heavy insulation are incorporated. Motors are designed for direct driving of refrigeration, heating and air-moving blowers and other applications in ratings up to ¼-hp. Made by **Fasco Industries Inc.**, Rochester 2, N. Y.

Circle 89, Page 225, for more data

Resistor 90

is highly stable at temperatures to 125 C

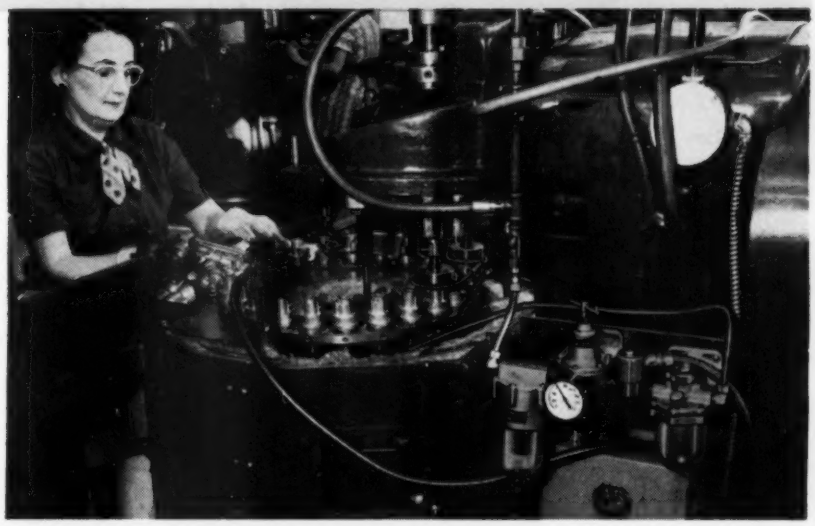
Used at low power, model PT 1000 carbon film resistor operates with high stability at any ambient temperature up to 125 C. Stability is better than ±0.03-per cent per year at 0.5-w rating. With a 1-w rating at 160 C, stability is better than ±0.1 per cent in 1000 hours. A hard borosilicate glass envelope



fusion-sealed to the end caps of the resistor provides mechanical protection and high temperature stability. The resistor is completely self-insulated. Resistance val-

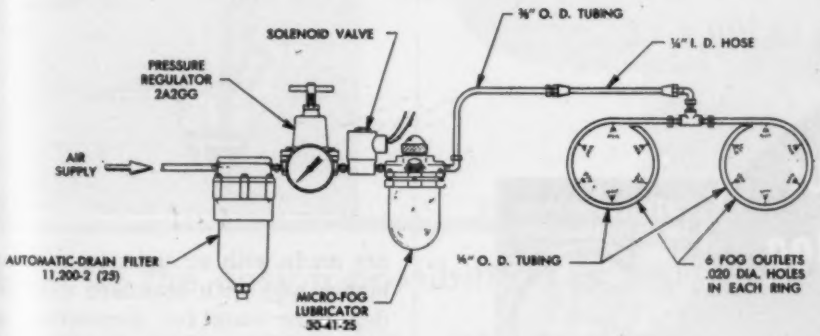
NORGREN MICRO-FOG LUBRICATION replaces coolant recirculating system

- **saves $13,000 a year by eliminating a parts degreasing operation**
- **increases tool life 300%**
- **substantial saving in lubricant**
- **eliminated coolant recirculating system.**



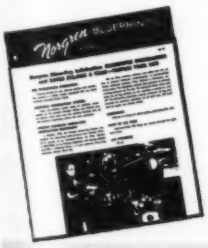
ANOTHER PROFITABLE WAY TO USE MICRO-FOG LUBRICATION

Norgren Micro-Fog Lubrication replaced a flood system on this tapping machine having two simultaneously operated chaser heads which are chasing threads on zinc, die-cast ignition lock barrels. A mixture of cutting oil, oleum spirits and Suntac No. 151 is now applied at rate of 20 drops per minute.



MICRO-FOG LUBRICATION SYSTEM DETAILS

Filter removes moisture and solids from air line to prevent lubricant contamination, and automatically drains collected moisture. Regulator reduces air line pressure to desired working pressure of 60 psi. Solenoid valve starts and stops Micro-Fog delivery as machine is turned on and off. Micro-Fog Lubricator creates air-borne oil fog and provides for accurate regulation of oil feed rate.



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The Complete Line of Micro-Fog Lubricators provides reliable lubrication for cylinders, tools, other air equipment...bearings, gears, chains, other machine components...as well as tool lubrication on light machining operations.

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3442 So. Elati, Englewood, Colo.

New Parts

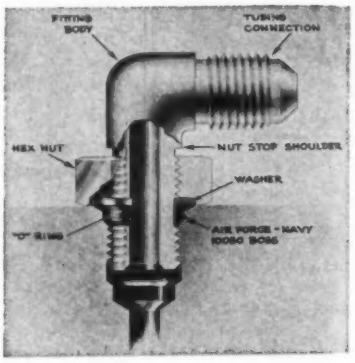
ues range from 1 ohm to 30 megohms. The resistors are available in sets with temperature coefficients matched to 1 ppm/deg C for high precision use over wide temperature ranges. Mounting can be done on leads capable of withstanding 15 lb pull. Overall size including weldable end studs is 1 3/16 in. with 1½ in. tinned leads. Made by **Pyrofilm Resistor Co.**, 8 Whippany St., Morristown, N. J.

Circle 90, Page 225, for more data

Tube Fittings 91

have O-ring seals to prevent leakage

Ring Seal fittings incorporate an O-ring and boss combination to provide a leakproof seal, even after repeated use. They require about the same space as other fittings and can be installed in required position in any material. Fittings



are made with straight or angular bodies and with standard JIC 37-deg flare ends for connection to tubing. Various fitting types, plugs and adapters are available in sizes to fit ¼, 5/16, ⅜, ½, ⅝, ¾ and 1-in. tubing. Made by **Monarch Machine Tool Co.**, Oak St., Sidney, O.

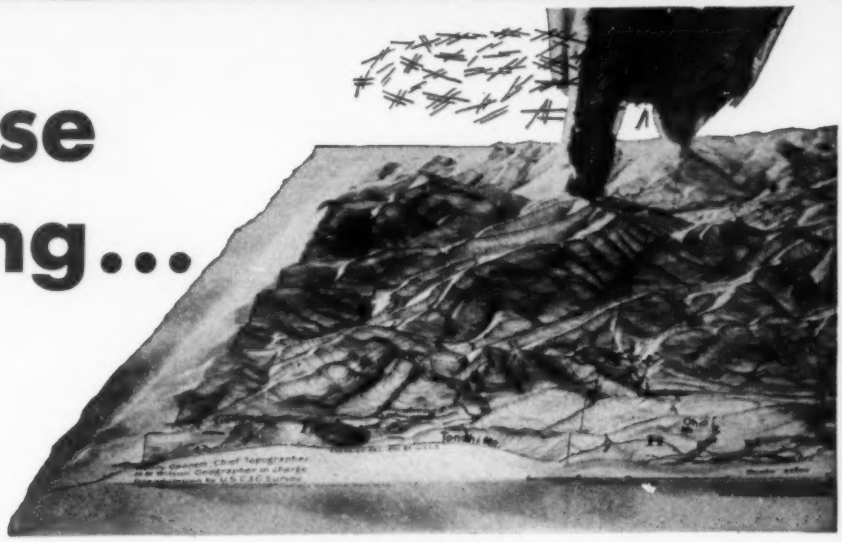
Circle 91, Page 225, for more data

Gear Pump 92

can have from two to six outlets

From two to six outlets are available on model Z3U multiple outlet gear pump, suitable for applications where several circuits of liquids or lubricants are required to work separately and independently of counter pressures. Uses include circulating lubricants in large diesel engines, gear reduction units

For precise forming...



Molded contour map made by **Aero Service Corp.**, Philadelphia 20, Pa.

crisp, clean appearance...

"Eye-Catcher Holder" Price Tags made by **The Hopp Press, Inc.**, New York 1, N. Y.

Look at the design possibilities in BAKELITE Brand Rigid Vinyl Sheets!

They give you formed parts with all the serviceability and eye-appeal of plastics *plus* highly accurate dimensions.

For example, the price tags above come in a variety of colors or are printed with photographs in four colors, perfectly registered. Glossy surfaces enhance their appearance. Slots in the tags accommodate changing prices.

The contour relief map gives terrain details in three dimensions. It's printed flat, then formed. Peaks, valleys, and other features are shown in their proper position. The map is smooth, tough, and durable. Pencil marks can be erased.

Fabrication is neat and easy with BAKELITE Rigid Vinyl Sheets because they're so uniform in size, thickness, and properties. Rejects stay at a minimum. That's why these sheets are being used for such a variety of jobs — luminous ceilings, price tags, three-dimensional signs and drafting instruments. They're light and tough, withstand handling, chemicals, oil. A damp cloth cleans them. They resist warping, cracking, and aging.

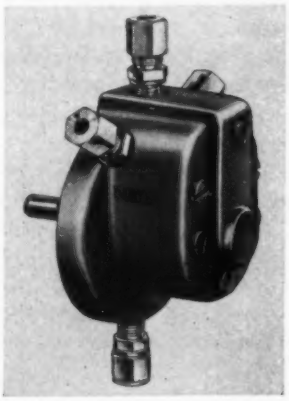
You can get BAKELITE Rigid Vinyl Sheets in a range of widths and thicknesses — clear transparent, or colored translucent or opaque. They may help *your* product design — saleswise and functionally. Write for information to Dept. KD-103.

BAKELITE
BRAND
Rigid Vinyl Sheets

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

New Parts



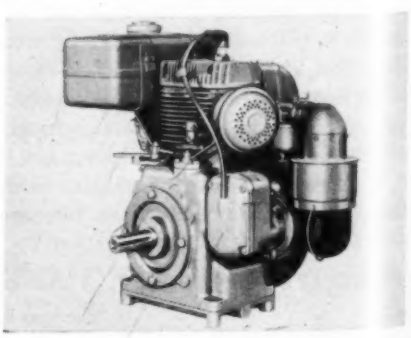
and machine tools. Automatically controlled dividing device enables each outlet to deliver equal or different quantities of lubricant. Use of one pair of gears provides precise operation and minimum power consumption. Pump operates on a rotary drive, direction of rotation being controlled by an adjustable sleeve on the driveshaft. It can have a reversible drive. Made by **Nathan Mfg. Corp.**, 45-02 Ditmars Blvd., Long Island City 5, N. Y.

Circle 92, Page 225, for more data

Heavy-Duty Engine 93

5.6-hp model operates at 1600 to 3600 rpm

This lightweight, four-cycle, heavy-duty engine, designated model ACN, has a piston displacement of 14.88 cu in. It operates within a speed range of 1600 to 3600 rpm, delivering from 2.3 to 5.6 hp, with torque of 92 to 104 lb-in. The air-cooled engine is equipped with tapered roller main bearings at both ends of the crankshaft and a gear-driven high tension magneto mounted on the outside. It has an impulse coupling for easy starting at low cranking speeds. Positive lubrication is provided by a pump-circulated splash system, and the piston is equipped with four



New Parts

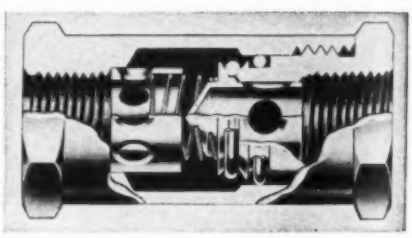
rings. This engine can be supplied with gear reducers of various ratios, clutch assemblies or with electric starter and generator, or electric starter alone. It can operate on gasoline, kerosene, butane, propane or natural gas. Made by **Wisconsin Motor Corp.**, 1910 S 53rd St., Milwaukee 14, Wis.

Circle 93, Page 225, for more data

Check Valve 94

confines pressure to strongest part of valve body

Sturdily constructed 200-1 series Circle Seal check valve utilizes a resilient O-ring as the sealing member, which provides absolutely tight sealing and chatter-free operation. Location of the O-ring confines pressure to the strongest



part of the valve body. The valve operates at pressure to 3000 psi. Cracking pressure of 0.5 to 1 psi. low pressure drop and sensitive leak-free reseating make the valve suitable for use in a variety of vacuum and low-pressure gas systems, as well as in high-pressure pneumatic or hydraulic circuits. Valve bodies of brass, aluminum, steel and stainless steel are available to fit ⅛ to 2 in. pipe. Made by **James-Pond-Clark**, 2181 E. Foothill Blvd., Pasadena 8, Calif.

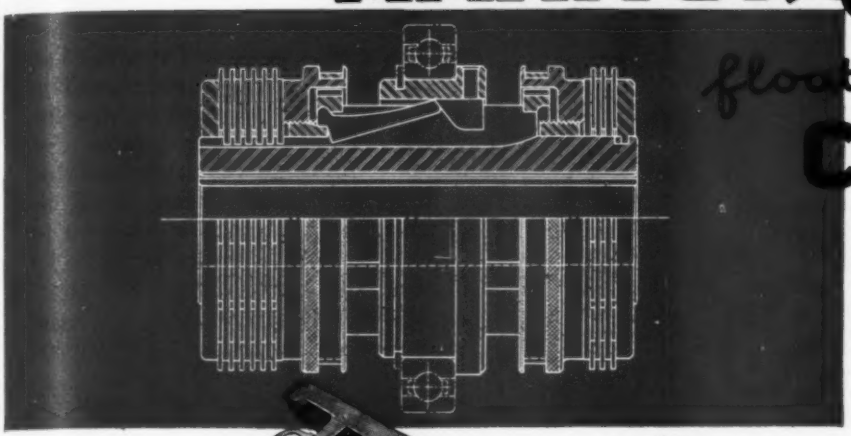
Circle 94, Page 225, for more data

Cold-Drawn Tubing 95

has smooth inside finish

Cold-drawn electricweld steel tubing can carry heavy torsion loads. It resists high-frequency vibration and has good weight-to-strength ratio in applications in which the loading is in all directions. For smooth inside surfaces and close control of outside and inside tolerances, the tubing is drawn over a mandrel and through a ring die simultaneously. For applications

MAXITORQ



floating disc
CLUTCH

FOR SPINDLE DRIVE CONTROL

on P&W Electrolimit Jig Borer

Positive and completely dependable start-and-stop control is just one of the reasons why so many precision machine builders prefer the Maxitorq clutch. Pratt & Whitney's engineers, in building this double Maxitorq clutch into the spindle drive of their new Electrolimit Jig Borers, also found that the clutch has sufficient braking action to act as a locking means when changing tools, yet has no drag when in neutral, so that the spindle may be easily turned by hand for indicating purposes.

Here, in a nutshell, are the principal Maxitorq advantages . . . simple, rugged design and construction which practically eliminate maintenance . . . immediate, positive engagement . . . equally positive disengagement without drag or heating . . . almost unlimited adaptability to drive requirements . . . and the most compact units available for a given power transmission requirement. Write us, outlining your needs. We will be glad to give you our recommendations and complete technical data.

Write Dept. MD-9 for full specifications and quotations.

4CJ55

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

New Parts

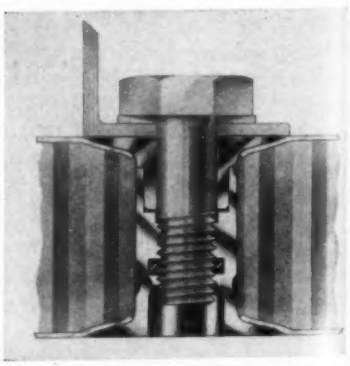
requiring close control of the outside diameter only, tubing is sink drawn, that is, passed through the die but not over the mandrel. The drawn-over-mandrel type can be used, without inside honing, for many cylinders requiring superior finish and close tolerances. Minimum tensile strengths range up to 70,000 psi; minimum yield strengths, up to 65,000 psi. Minimum tensile strength of the sink drawn tubing ranges up to 70,000 psi; minimum yield strengths, up to 55,000 psi. Tubing is available in sizes ranging from ¾ to 2¼ in. OD. Wall thicknesses range from 0.035 to 0.134-in. Made by **Jones & Laughlin Steel Corp.**, 3 Gateway Center, Pittsburgh 30, Pa.

Circle 95, Page 225, for more data

Self-Locking Spacer 96

is threaded for sandwich structure use

Designed for applications where light weight and vibration resistance are required, Fasco self-locking threaded type bolt spacer is easily installed without special tools. It consists of a plug and a tapped sleeve containing a self-locking nylon insert. The sleeve receives the attaching bolt,



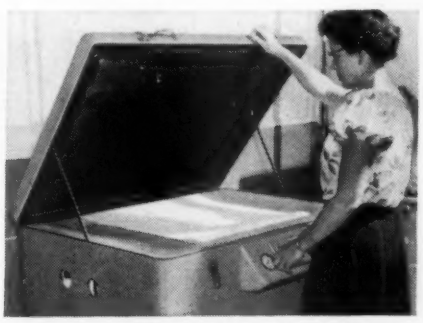
eliminating use of a nut. Spacer provides means for attaching conduit, cables, instruments and other equipment to sandwich-type structures without danger of crushing panels. It can be used wherever fastening takeup must be limited to a specified grip length. These reusable, anodized 24ST-4 aluminum alloy fasteners are available in No. 10 screw size for panel thicknesses from ½ to 1¼ in. No. 8 and ¼-

Glass containers for every purpose are designed and manufactured by Owens-Illinois Glass Company—over 100 billion units made in last 25 years

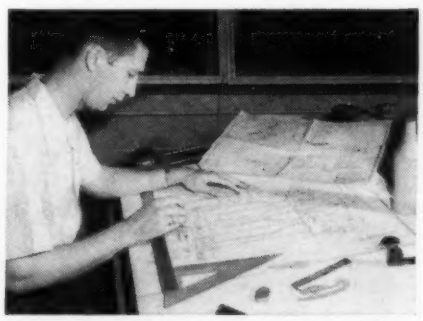
More than 3,000 new designs per year
—without a "bottleneck" in drafting

In the Design Development Department of the Owens-Illinois Glass Company, Toledo, Ohio, no time is lost in tedious redrafting. A simple short cut involving the use of Kodagraph Autopositive Paper and Kodalith Film *gives customers fast service . . . saves dollars every day.* Chances are you can adapt this technique to your own routines.

Big head start. Kodalith Film prints of elements which are repeated from time to time are kept on file. When a new design calls for any of these elements, the draftsman merely tapes the right films on clear acetate *and orders an Autopositive.* No redrafting!



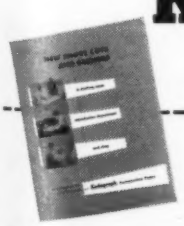
A positive photographic intermediate is produced *directly* by exposing the "paste-up" in contact with Kodagraph Autopositive Paper, then processing the print in standard photographic solutions. No negative step . . . *easy room light operation.*



New design is added to the Autopositive, which has dense photographic black lines on a clean white translucent base. Required number of shop prints—each crisp and uniform—are produced from this master, which can also be used later on for minor revisions.

Kodagraph Autopositive Paper

"THE BIG NEW PLUS" in engineering drawing reproduction



Shows all the ways you can save with Kodagraph Autopositive Paper.

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY
Industrial Photographic Division, Rochester 4, N. Y.

19

Gentlemen: Please send me a copy of "New Short Cuts and Savings."

Name _____ Position _____

Company _____ Street _____

City _____ Zone _____ State _____

Kodak

New Parts

in.-24 screw sizes will soon be available. Made by **Delron Co.**, Fasco Div., 5224 Southern Ave., South Gate, Calif.

Circle 96, Page 225, for more data

Lubricators 97

for 32, 200 and 300 bearing-inch capacities

Five new models of Micro-Fog lubricators are available in ¼, ¾ and 1-in. pipe sizes with capacities to lubricate up to 32, 200 and 300 bearing inches, respectively. Models with 1-qt capacity oil reservoirs are made in each of the three pipe sizes; the 4½-gal model is made in ¾ and 1-in. sizes. The ¼-in. lubricator uses 2 cfm of air at rated operating pressure of 20 psi; the ¾-in. model uses 5 cfm

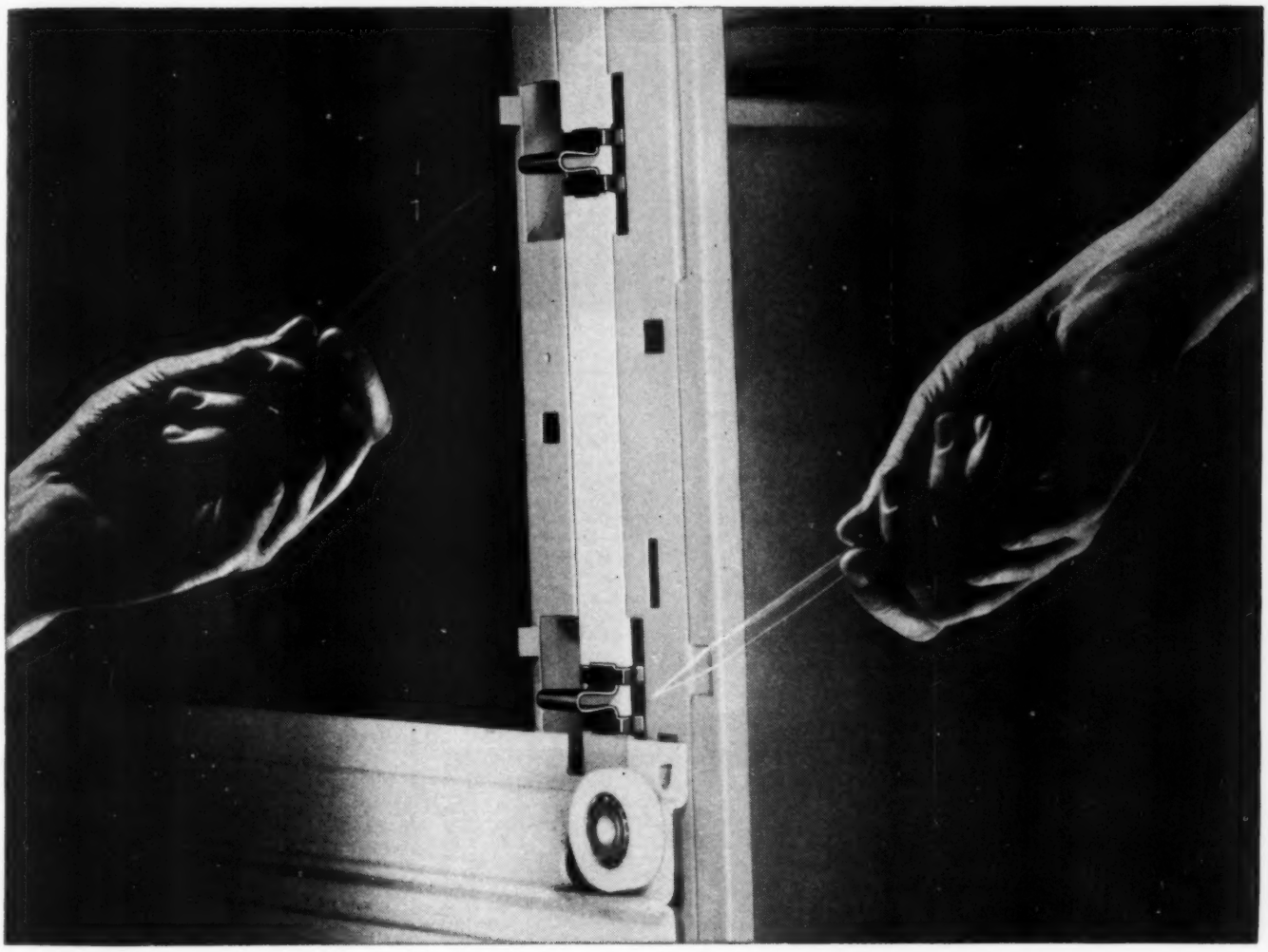
at 23 psi; and the 1-in. model uses 7½ cfm at 40 psi. Lubricators operate automatically and deliver a uniform rate of oil feed regardless of the supply of oil in the reservoir. The oil mist lowers the operating temperature of high-speed rotating parts, and the slight air pressure in bearing or gear housings prevents entry of dust, coolants or other foreign matter. Made by **C. A. Norgren Co.**, 3442 S. Elati St., Englewood, Colo.

Circle 97, Page 225, for more data

Tube Fittings 98

are made of plastic for plastic tubing

Line of Du Pont Zytel polyamide resin fittings for plastic tubing includes elbows, tees, reducers, adapters, plugs, caps and bulkheads. No preparation of tubing is necessary; attachment is accom-



Engineered by Tinnerman . . .

SPEED CLIPS® GIVE DESKS EXTRA MODEL FLEXIBILITY. . . and save money!

Here's the special SPEED CLIP that enabled the General Fireproofing Company, Youngstown, Ohio, to build maximum flexibility into its new "Generalaire" office furniture. A relatively small number of basic units can be interchanged to produce 46 different desk and table models. General Fireproofing reduces manufacturing and shipping costs; dealers have fewer parts to stock and handle!

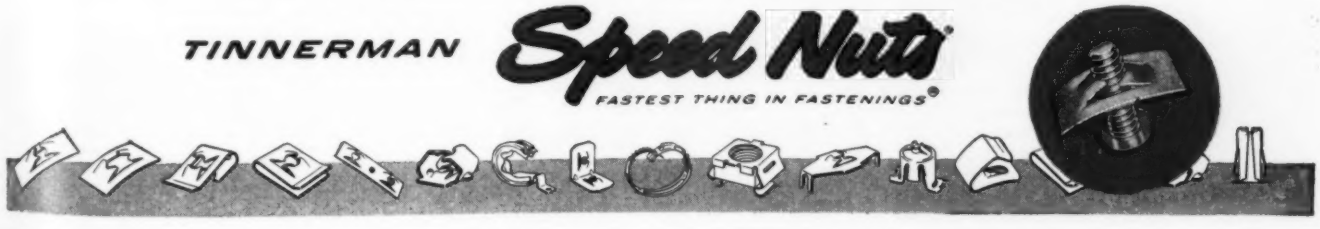
This one-piece, spring-steel SPEED CLIP snaps easily and quickly into place by hand. It replaces a costly five-piece locking bar latch mechanism that had to be factory-installed in left- and right-hand assemblies. Now, SPEED CLIPS make it possible to ship knockdown locking bars to dealers who then build left- and right-hand assemblies from basic units to fill customers' orders. What's more, Generalaire desks are assembled throughout with 20 or more SPEED NUT brand fasteners which contribute greatly to this flexibility.

A free Tinnerman Fastening Analysis of your products may show similar assembly advantages with important production savings. See your Tinnerman representative soon and write for Fastening Analysis Service Bulletin No. 336.

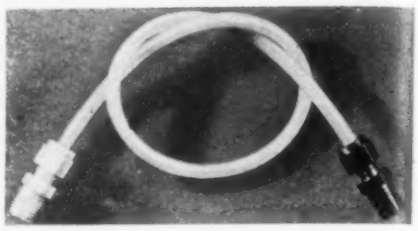
TINNERMAN PRODUCTS, INC., Box 6688, Dept. 12, Cleveland 1, Ohio

Canada: Dominion Fasteners, Ltd., Hamilton, Ontario. *Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *France:* Aerocessoires Simmonds, S. A., 7 rue Henri Barbusse, Levallois, (Seine). *Germany:* Hans Sickinger GmbH "MECANO", Lemgo-i-Lippe.

TINNERMAN Speed Nuts® FASTEST THING IN FASTENINGS®



New Parts



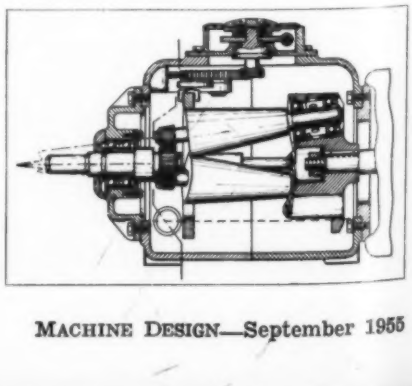
plished by inserting the tubing in the fitting and tightening the nut. Swagelok design provides strong, torque-free and leakproof seals or joints at all tubing connections. Two ferrules and a threaded chuck grasp the tube tightly. Neither sleeves nor inserts are necessary. Plastic fitting is shown on the left; brass fitting is on the right. Made by **Crawford Fitting Co.,** 884 E. 140th St., Cleveland 10, O.

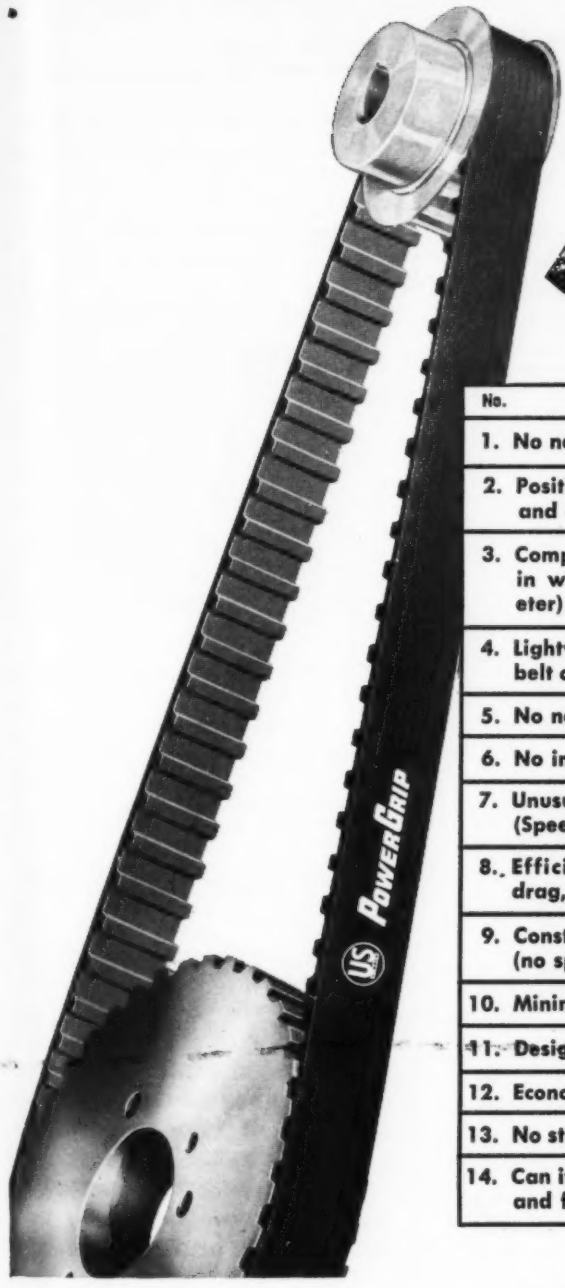
Circle 98, Page 225, for more data

Transmission 99

permits accurate adjustment above and below input speed

Designed to provide small and extremely accurate speed adjustments, this type K Corrector Drive incorporates both an adjustable-speed drive and a built-in differential. It is available with or without a motor. Various models provide output speed ranges of 4 to 6 rpm to 4550 to 6150 rpm. Input speed is transmitted to the output shaft by means of three tapered rollers, a control ring which encircles the rollers, and bevel pinions fixed to the large end of the rollers. For most applications the transmission is equipped with built-in gear reduction so that the range of output speed is both above and below the input speed. For applications where the input speed is low or variable, the transmission is equipped with a spring-loading device which provides the traction loading between rollers and the encircling control ring. The entire as-





"√" in your transmission belt needs

No. Advantages	PowerGrip "Timing" Belt	Chain	Gear	V-Belts	Flat Belts
1. No need for lubrication	√				
2. Positive elimination of slip and creep	√				
3. Completely compact (Both in width and pulley diameter)	√				
4. Lightweight (Heavy duty belt only 0.1 lb./ft./in.)	√				
5. No noise or vibration	√				
6. No initial tension	√				
7. Unusual speed range (Speeds up to 12,000 FPM)	√				
8. Efficient (Elim. heat, lube drag, high bearing loads)	√				
9. Constant angular velocity (no speed fluctuation)	√				
10. Minimum backlash	√				
11. Design flexibility	√				
12. Economical	√				
13. No stretch	√				
14. Can it be completely housed and forgotten?	√				

Note that the U. S. PowerGrip "Timing" Belt takes a "√" after every advantage

While every type of drive has certain advantages, *no* type of power transmission possesses *so many* advantages as the U.S. PowerGrip "Timing" Belt drive. For example, *it is the only positive drive that never needs lubrication.*

THE LIST OF USES GROWS DAY BY DAY! Power production machinery in every field is made more efficient, volume of production increased, and maintenance costs lowered with this amazing belt. The list of OEM applications grows too numerous to mention. U.S. PowerGrip has streamlined hundreds of products... made them sell above competition. Some equipment would not be in existence at all, if it weren't for this great belt.

Immediate delivery of stock drives with ratios up to 12 to 1 is obtainable from any of United States Rubber Company's selected distributors or any of the 27 "U.S." District Sales Offices, or the address below.

Send for free illustrated manual, complete with standard drive tables.

"U. S." Research perfects it..."U. S." Production builds it...U. S. Industry depends on it.

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes Molded and Extruded Rubber and Plastic Products • Protective Linings and Coatings • Conductive Rubber • Adhesives • Roll Coverings • Mats and Matting

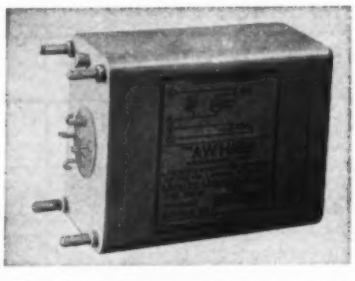
sembly can be mounted with four bolts. A variety of special controls, such as remote mechanical, electrical, pneumatic or hydraulic, are available to provide automatic speed correction in response to a control signal. Made by **Graham Transmissions Inc.**, Menomonee Falls, Wis.

Circle 99, Page 225, for more data

Time Delay Relays 100

provide a proportional delayed reset

These time delay relays are available hermetically sealed in an extruded aluminum housing, as shown, or in a standard dust cover. The hermetic model is available with a glass and metal header or



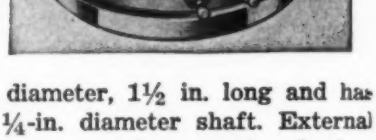
an AN connector, for four-stud or bracket mounting. The relays provide a proportional delayed reset after current interruption. Time delays can be from 5 seconds to 1 hour, and reset times can be from 30 seconds to 7½ minutes. Standard or governed dc or 60 or 400-cycle ac motors can be furnished on the relays. All models meet military requirements. Made by **A. W. Haydon Co.**, 232 N. Elm St., Waterbury, Conn.

Circle 100, Page 225, for more data

Potentiometer 101

is designed for servo or bushing mounting

Series Y Helipot is a single-turn, continuous rotation precision potentiometer for servo or bushing mounting. As many as 14 sections can be ganged on a common shaft during manufacture, with as many as 17 taps added to any section. Each tap is spot-welded to a single turn of resistance wire, assuring a strong connection. Operating range is −55 to 80 C. Power rating is 3.4 w at 25 C and 2.5 w at 40 C. Linear models have a standard linearity of ±0.5-per cent. Standard conformity in models having nonlinear output is ±1 per cent. Potentiometer is 1¾ in



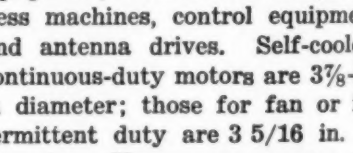
in diameter, 1½ in. long and has a ¼-in. diameter shaft. External clamps provide accurate phasing. Made by **Helipot Corp.**, 916 Meridian Ave., South Pasadena, Calif

Circle 101, Page 225, for more data

Induction Motors 102

small units are rated from 1/100 to 1/10-hp

Applications for a new line of small, lightweight capacitor induction motors include electronic equipment, automatic devices, business machines, control equipment and antenna drives. Self-cooled continuous-duty motors are 3⅞-in. in diameter; those for fan or intermittent duty are 3 5/16 in. in diameter. Horsepower ranges are from 1/100 to 1/10-hp at all standard voltages, one, two or three-



phase. Motors are made for 60 and 400-cycle operation. The 60-cycle models have speed ranges of 1100, 1650 and 3300 rpm; ranges for 400-cycle models are 5600, 6800, 11,000 and 22,000 rpm. All motors are shock resistant. They

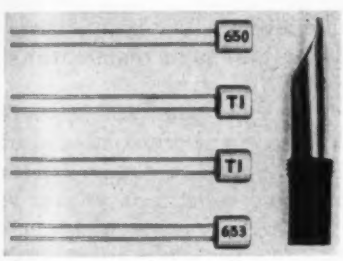
can be provided with ball or sleeve bearings; either Class A or H insulation; and bracket, face or strap mounting. Shaft configuration and size are variable to suit applications. Made by **Eastern Air Devices Inc.**, 385 Central Ave., Dover, N. H.

Circle 102, Page 225, for more data

Silicon Diodes 103

maintain voltage reference in any environment

These four silicon diodes operate with reverse breakdown voltage, measured at 5 ma, ranging from 3.7 to 8.0 v. Breakdown voltage temperature coefficients in the range from −55 to 150 C are extremely small. These temperature coefficients, which can be positive



or negative, are combined with low dynamic resistance in the breakdown region to provide accurate, constant voltage reference. Hermetically sealed in miniature cans, the diodes maintain accurate reference indefinitely regardless of variation in moisture, altitude or other environmental conditions. Total power dissipation is 150 mw at 25 C and 40 mw at an ambient temperature of 150 C. Maximum average rectified forward current ranges from 90 to 125 ma at 25 C. Maximum reverse current is 0.1-microampere at −1 v at 25 C. Made by **Texas Instruments Inc.**, 6000 Lemmon Ave., Dallas 9, Tex.

Circle 103, Page 225, for more data

Shut-Off Valve 104

can be normally off or normally on

Power-All HV-250 pneumatic shut-off valve can be used at pressure up to 150 psi. It permits the passage of 52 cfm of air at 100 psi. The valve can be used as normally off or normally on. It has holes

New Parts

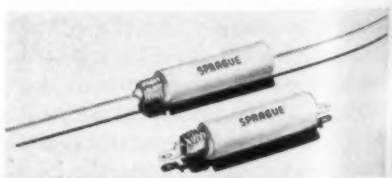
for horizontal or vertical mounting, or it can be mounted with a pipe nipple only. Currently available in ¼-in. port size, the valves will also be offered in ⅛ and ⅜-in. sizes. Made by **Power-All Products**, 1093 71st Ave., Oakland, Calif.

Circle 104, Page 225, for more data

Paper Capacitors 105

metallized paper type operate reliably at high temperatures

Subminiature type 118P Metal-Clad metallized paper capacitors operate at 125 C without voltage derating. Insulation resistance is also very high. The capacitors withstand dielectric test of twice rated voltage.



They are made with self-healing dielectric, complete hermetic sealing, glass-to-metal solder-seal terminals and corrosion-resistant cases. Both standard wire leads and solder tab terminals are available. Capacitors meet environmental tests of MIL-C-25A. Made by **Sprague Electric Co.**, 167 Marshall St., North Adams, Mass.

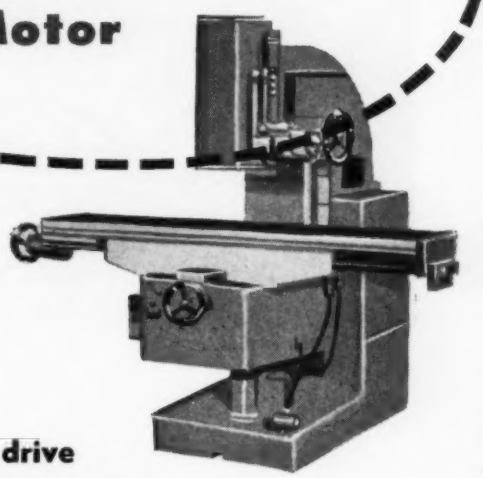
Circle 105, Page 225, for more data

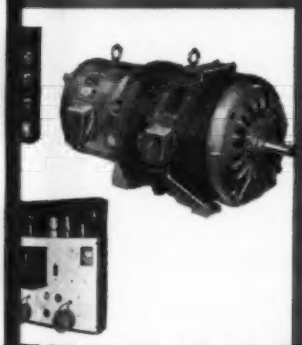
Lubricating Unit 106

combines air filter, regulator and lubricator

Lub-air-ator, composed of air filter, regulator and lubricator, is fully automatic, easily cleaned and can be serviced without removal from the pipe line. The filtering unit employs a large sintered bronze

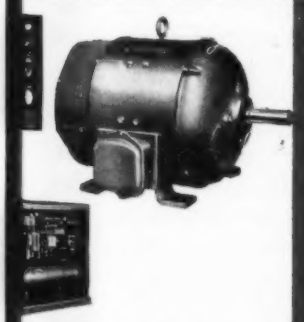
You can speed-up your machine-tool operation *when this button* operates a LOUIS ALLIS Adjustable Speed Drive or Special Motor





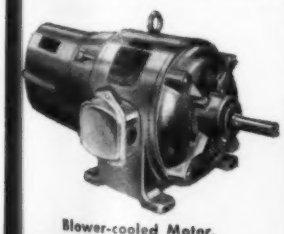
Almato-Speede® Drive

puts precision speed control at the operator's fingertips. ¾ to 75 hp. AC. Uses eddy current clutch to provide speed ranges up to 17:1. Tachometer feedback circuit offers precise speed regulation. Optional features available include dynamic braking, torque control, inching, jogging, multimotor operation and range drives.



Select-A-Spede Drive

5 to 200 hp. Magnetic amplifier and adjustable voltage control provides superior speed regulation from 1/8 base speed to full speed. Optional control features include reversing, dynamic braking, jogging, special programming or sequencing, extra wide speed range. Electronic and Static Select-A-Spede Drives also available in smaller horsepower ranges. Speed regulation to ½% in ranges up to 100:1. All operate from AC source.



Blower-cooled Motor.

Rolled-shell, Shaftless Motor.

Special Motors

You don't have to compromise — or take a unit that "almost" does your job when you choose Louis Allis. On short notice you can get a unit exactly engineered and designed for your job. Some of the special characteristics built into Louis Allis motors for specialized machine-tool use include high starting torque, high slip, multi-speed operation, and rapid reversing. Other special features may include precision balance, high-frequency operation, and special-duty cycles. For these or any other special electrical or mechanical modification for machine tool work, see Louis Allis first.

Get the precision drive your machine tool requires from the *complete* Louis Allis Line

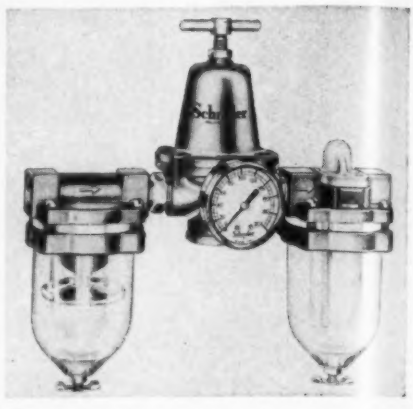
New precision machine tools call for precision drives. That's where Louis Allis fits into *your* picture. Louis Allis has the exact unit you need because it has the most complete line of motors and drives available to industry.

And if one of Louis Allis's wide range of stock motors doesn't exactly fit your job's requirements, you can get prompt delivery on a unit specially designed to give you the electrical or mechanical characteristics you need. Call your nearby Louis Allis Sales Engineer for motor application assistance on your problem.

See our exhibit,
Production Engineering Show,
Sept. 6 to 16, Navy Pier, Chicago,
Booth No. 119-120.

THE LOUIS ALLIS CO.
MILWAUKEE 7, WISCONSIN

New Parts



filter, baffle plate and drain cock for blowing out water and accumulated foreign matter. The regulator reduces inlet pressure of 250 psi down to 5 to 125 psi. A pressure gage can be mounted at the front or rear of the regulator. Oil flow in the lubricator unit is adjusted by means of a vibration-proof thumbwheel. A transparent bowl, with half-pint capacity, indicates oil level. The lubricator is available in three sizes, to fit ¼, ⅜ and ½-in. NPT. Made by Scovill Mfg. Co. Inc., A. Schrader's Son Div., 470 Vanderbilt Ave., Brooklyn 38, N. Y.

Circle 106, Page 225, for more data

Elapsed Time Meter 107

operates on 115-v, 60-cycle ac

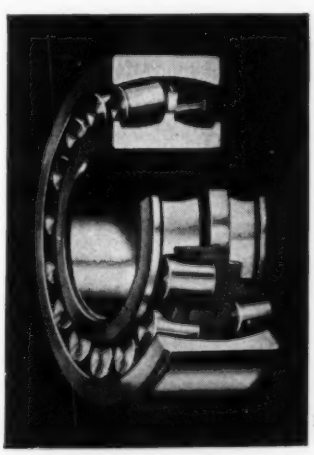
Model 7008 running time meter indicates operating time up to 10,000 hours on a dial type face. Operating on 115-v, 60-cycle ac, the meter has a power drain of approximately 2 w. It is hermetically sealed in accordance with specification MIL-I-7793 (AER) and meets military shock and vibration requirements. The meter is 1½ in. in diameter x 2¾ in. long and weighs less than 6 oz. It mounts either behind or in front of the mounting panel with screws through four 0.140-in. diameter mounting holes. Electrical

TORRINGTON *Spherical Roller Bearings are used in every kind of heavy duty application requiring high load capacity, resistance to shock and wear under conditions of misalignment.*

Courtesy of the Ohio Oil Co.

TORRINGTON Spherical Roller Bearings

are designed with machined, cast-bronze, land-riding cages—one for each path of rollers—to assure true rolling operation



Other TORRINGTON SPHERICAL ROLLER BEARING features are equally important in assuring top performance. Contact surfaces are precision ground for even load distribution, long bearing life. Rollers and races are carefully heat treated to give maximum resistance to shock and wear.

An integral center flange gives positive radial stability and accurate positioning of thrust loads—an essential factor for longer service life. Contact surfaces possess geometrical conformity, giving ultimate load carrying capacity.

These are reasons why TORRINGTON SPHERICAL ROLLER BEARINGS give you long, low-maintenance service in the toughest, heavy-duty applications. Get the most for your bearing dollar—specify TORRINGTON.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON SPHERICAL ROLLER BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

New Parts

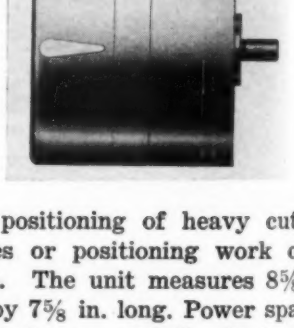
connections are from the back through solder type glass-to-metal sealed terminals. The indicator is also available with an external pointer which can be set to schedule replacement of machine components whose life expectancy is known. Made by **Haydon Mfg. Co.**, 245 E. Elm St., Torrington, Conn.

Circle 107, Page 225, for more data

Brake-Motor 108

intermittent duty type has high starting torque

Starting torques of this intermittent duty, nonventilated type brake-motor are up to 500 per cent of running torque, sufficient to overcome starting inertias of heavy loads or those that are difficult to move. Applications include raising



and positioning of heavy cutting blades or positioning work on a lathe. The unit measures 8⅝ in. OD by 7⅝ in. long. Power span is 5 minutes on and 5 minutes off. Brake-motors are polyphase, totally enclosed and can be flange mounted in any position. Motors are rated from ⅓ to 1½ hp; brakes, from ½ to 25 ft-lb. Made by **Reuland Electric Co.**, 3001 W. Mission Rd., Alhambra, Calif.

Circle 108, Page 225, for more data

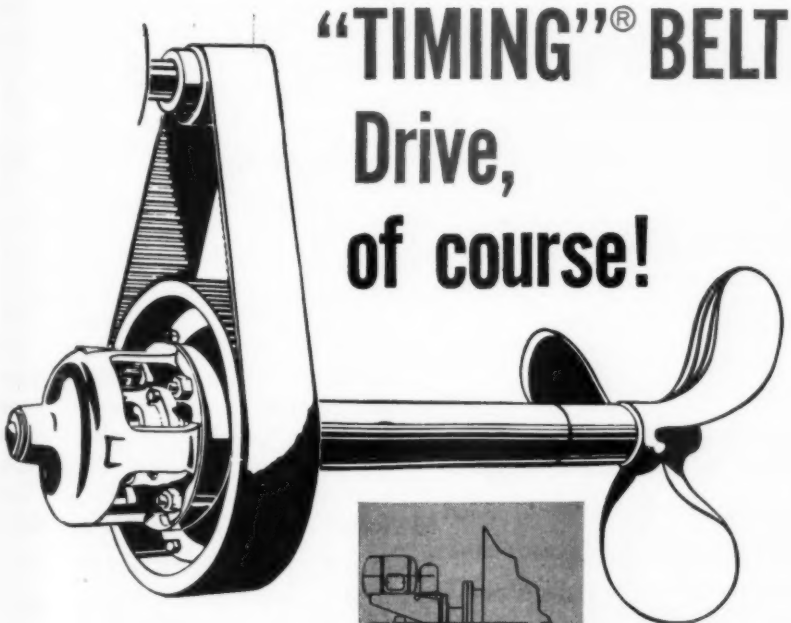
Thermostats 109

operate at temperatures between −50 and 500 F

Line of thermostats, ¼-in. in diameter and less than 2½ in. long, is designed for precise temperature control or heat detection applications in heated equipment, bearings, pumps and similar products. Units weigh approximately 1 oz and can be set to actuate at any specified temperature between −50 and 500 F. Contacts can be nor-

What other single design improvement yields so many selling features?

adopting a Gilmer** "TIMING"® BELT Drive, of course!



Complete Mixer installed on side of tank.

*Jensen Engineering Company, Tulsa, Okla.

**The ORIGINAL Timing Belt.

A good example is the *JENSEN Model "BA" Shortstir Mixer**. Here is a simple 4-1 reduction drive from motor to propeller shaft... yet look at all the new selling features the adoption of a Gilmer "TIMING" BELT Drive provides the manufacturer! (The quotes below are taken verbatim from Jensen's *own literature.)*

"The JENSEN Shortstir Mixer, using the Timing Belt Drive, introduces a simple, rugged method of transmitting power from the motor to the propeller. It is much more compact, weight is greatly decreased, and elimination of couplings provides considerably less overhang from the motor.

"Motor alignment is set at the factory and a 'single bolt' adjustment for initial belt tension is the only adjustment required for the life of the belt.

"A Nylon facing and steel cable tensile members assure an almost unlimited belt life. Positive engagement of belt teeth with pulley grooves prevents slippage, power loss, and overloaded bearings common to most types of belt drives. Compactness greatly reduces vibration.

"No lubrication or belt dressing is required. Oil, however, does not harm the belt. All the advantages of a positive gear drive are accomplished plus the quietness and economy of a belt drive."

Stock or special Gilmer "TIMING" BELT Drives are obtainable through your local NYB&P Distributor. Many design engineers are now making profitable use of the 200-page "Timing" Belt Drive Engineering Handbook. If you are engaged in designing machinery and do not have a copy, write us on your company letterhead.

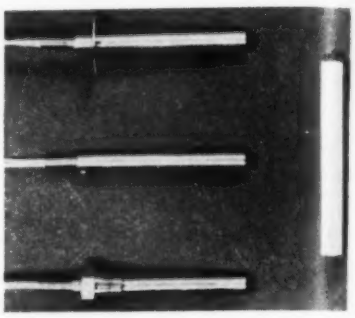
Gilmer V-BELTS AND "TIMING®" BELTS

NYB&P INDUSTRIAL RUBBER PRODUCTS

NYB&P — NEW YORK BELTING & PACKING CO. (Founded 1846) — 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products

New Parts



mally closed or normally open. Head styles are basic cartridge style for insertion into a cylindrical cavity, two screw-in models with hexagonal heads for ⅛ and ⅜-in. bushings or tapped holes, and a flange head unit for surface mounting. Standard thermostat is rated to handle 1 amp, 115 v ac; larger loads can be handled with a relay. Cartridge bodies and mounting accessories are polished stainless steel and wiring leads are Teflon coated. Made by **Fenwal Inc.**, Pleasant St., Ashland, Mass.

Circle 109, Page 225, for more data

Electronic Timer 110

is self-recycling

Model S44 cold cathode tube electronic timer can produce a repetitive series of circuit closures automatically. The load circuit remains closed for a fixed time of approximately 60 milliseconds, and the time between circuit closures is adjustable to any value from 0.03-second to 24 seconds. The length of time the load-circuit stays

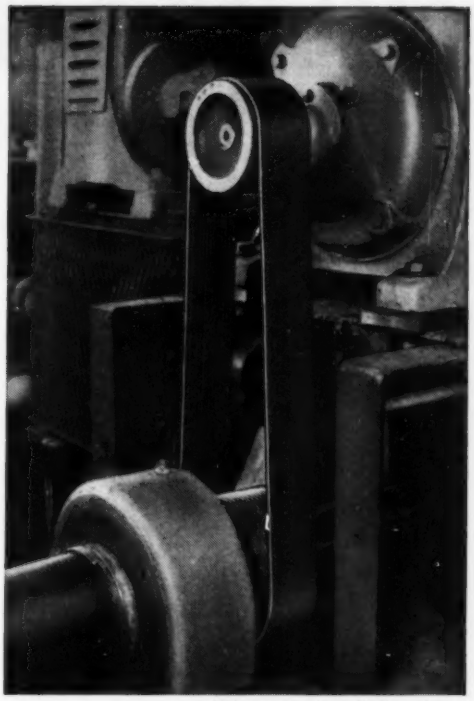
closed can be increased by connecting capacitance to terminals provided for this purpose, or the hold-in time can be shortened by connecting resistance across those terminals. The two single-pole, sin-

(*Continued on Page* 274)

R/M *Poly-V*® *Drive*

PLUS R/M ENGINEERING SERVICE . . . . . SOLVES DIFFICULT DRIVE DESIGN PROBLEMS

Design engineers in many industries are discovering the outstanding design advantages of the R/M Poly-V Drive . . . and the service offered by the Raybestos-Manhattan engineers who developed this revolutionary and completely new concept of power transmission. Ideal for original equipment design applications, R/M's Poly-V Drive combines the high V-groove grip of V-belts with the strength and simplicity of flat belts in a *single* endless belt drive.



(Belmont Co. installation photo.)

R/M ***Poly-V*** in metal working

To help you solve difficult drive design problems with this exclusive, patented R/M development, Raybestos-Manhattan offers complete engineering data and service at no obligation. R/M engineers will gladly demonstrate advantages of R/M Poly-V Drive never before possible with ordinary V-belt drives. They are prepared to work personally with you and your staff . . . to study your drive design problems and make the proper recommendations.

Let R/M engineers show you why the R/M Poly-V Drive is proving the greatest advance in power transmission drive development since the multiple V-belt . . . for the improved design of both new and existing equipment. Write to Raybestos-Manhattan, Inc., Manhattan Rubber Division, Passaic, N. J.

®Poly-V is a registered Raybestos-Manhattan trade mark.

NO MATCHING PROBLEMS — The Poly-V Belt is a single unit across full width of the sheave to give uniform pull, greater dependability and longer service because drive life is not limited to individual V-belt life.

CONSTANT PITCH DIAMETER — Poly-V Drive eliminates sinking of belt in sheave grooves . . . maintains constant pitch diameter and speed ratio at all loads for smoother, cooler drive operation . . . less wear on belt and sheaves.

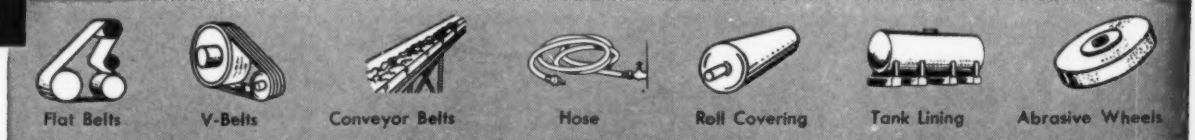
ONLY TWO BELT CROSS SECTIONS — The entire field of heavy duty power transmission belt requirement is covered by two Poly-V Belt cross sections, instead of five multiple V-belt cross sections . . . simplifying drive inventories and increasing their interchangeability.

GREATER POWER CAPACITY WITH NARROWER SHEAVES — Because Poly-V Belt has higher horsepower capacity per inch of width, sheaves are narrower . . . you get more power in the same space as multiple V-belt drives, or equal power in less space.

RM-537

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.



Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings
Asbestos Textiles • Packings • Engineered, Plastic, and Sintered Metal Products • Bowling Balls

CALL ON R/M ENGINEERING SERVICE

OUTSTANDING FOR PUMPS—R/M UNIVERSAL PACKINGS

The packings pictured above—R/M Universal Plastic Packings—are precisely engineered to the requirements of pumps and valve stems. Their performance under many different service conditions is uniformly outstanding. They can always be counted on to provide low friction and the resistance desired to materials handled, pressure and heat. The superlative ability of these packings to retain their lubrication is but one of the many secrets of their success—the lubricants are locked in so securely that even after wear sets in, the effectiveness of the bearing surface remains unchanged. R/M Universal Packings are particularly popular with maintenance men because they permit the practice of preventive rather than corrective maintenance.

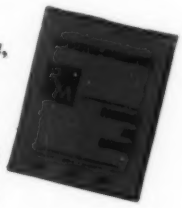
The complete R/M line includes packings and gasket sheets for use against air, gas, water, steam, oil, chemicals, solvents, food products and hydraulic fluids. R/M also makes a wide variety of "TEFLON"* products and an unusual number of asbestos textiles. If you have problems involving any of these materials or products, feel free to call on R/M's specialized engineering service.

**DuPont's trade-mark for its tetrafluoroethylene resin*

For booklet shown, or other data, write, phone or wire:

PACKING DIVISION
Raybestos Manhattan, Inc.
Passaic, N.J. • Gregory 3-2000

ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa. • Manheim 5-2211



R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METALS, ENGINEERED PLASTICS

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Fan Belts and Radiator Hose

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS

MOLDED PARTS—Rubber • Silicone • Nylon

Molded parts of natural or oil-proof synthetic rubber, silicone or nylon are custom-engineered and mass produced by R/M for long, trouble-free performance under all conditions of use. R/M engineers, backed with over 60 years' molding experience, help you determine the right design and material for your application . . . to meet new requirements or to overcome troublesome conditions caused by parts now in use. You get the same dependable engineering help also in cut and extruded parts made to your special order. R/M's "Exclusive Features" book describes other R/M products . . . rubber hose, conveyor and transmission belts, V-belts. Let R/M specialists work with you.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
Gregory 3-2000

FRICTION MATERIALS

Unlike other manufacturers, R/M works with *all* kinds of friction materials, from asbestos to sintered metals. This means that when you consult an R/M engineer you can be sure of completely unbiased advice on which materials are best for your application.

Raybestos-Manhattan has been the world's largest maker of friction materials for over 50 years. Whatever your brake or clutch requirements, count on R/M experience, and R/M manufacturing and testing facilities, for a friction material exactly suited to your needs.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
6010 Northwest Highway
Chicago 31, Ill.
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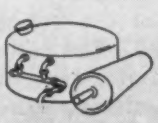
RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts



Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

New Parts

(*Continued from Page* 270)

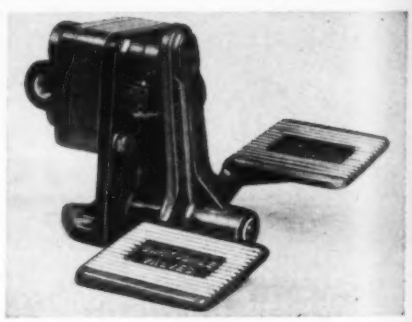
gle-throw contactors of this timer are rated 8 amp noninductive at 115 v ac. The timer does not require a warm-up period, nor does it consume power during the off cycle. It measures 3⅞ x 4⅞ x 3 in. Made by **Farmer Electric Co.**, 21 Mossfield Rd., Waban 68, Mass.

Circle 110, Page 225, for more data

Foot-Operated Valve 111

controls air pressure to 250 psi

This four-way, foot-operated air valve incorporates the Shear-Seal principle of a pressure-balanced, self-aligning valve seat in constant contact with a rotor containing flow passages. Any port can be used as the pressure port, and the



valve body can be installed in one of four positions 90 deg from each other to provide the most convenient piping. Three possible settings are spring return to either extreme, spring return to the center, or without spring return. Valves are brass, bronze, stainless steel and aluminum in ¼ and ⅜-in. port sizes. Made by **Barksdale Valves**, 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle 111, Page 225, for more data

Power Sources 112

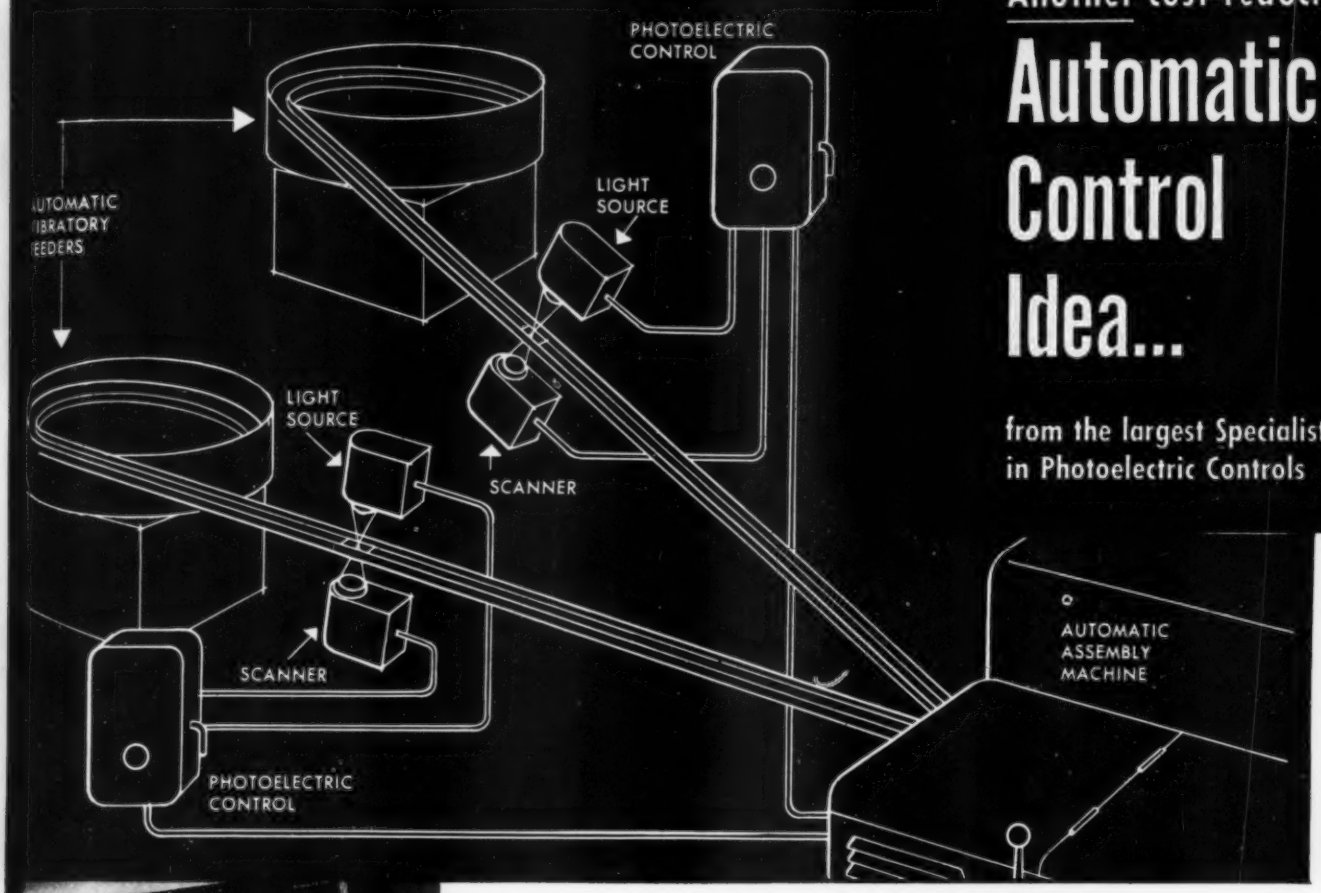
deliver up to 10 kw

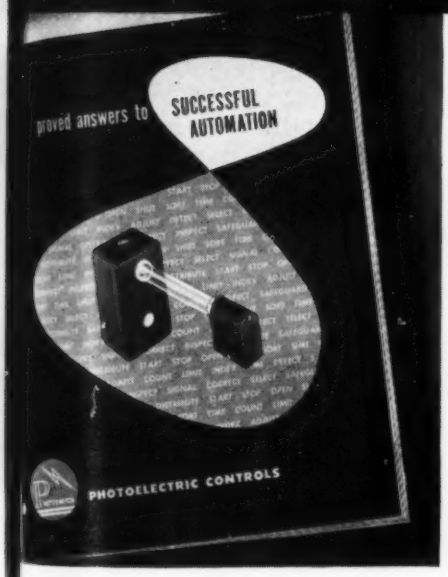
Compact and lightweight Mo-Bil-Ac portable power sources deliver 3, 5 or 10 kw of single or polyphase ac at 110-220 v. Each unit utilizes as a prime mover the engine of the vehicle in which it is carried. The power supply is composed of a two-pole alternator and a regulator. The alternator can be mounted under the hood of a vehicle and driven by a V-belt from

Another cost-reducing

Automatic Control Idea...

from the largest Specialists in Photoelectric Controls





Continuous-Feed Monitoring to Safeguard Assembly Machine

Problem: To achieve fully automatic operation by eliminating the hazard of damage due to stoppage of parts fed to an assembly machine.

Solution: Gravity feed tracks carrying small parts from continuous vibratory feeders run between scanner and light source of Photoswitch Photoelectric Control Sets. Light beams pass through a small window in the bottom of each feed track, and are normally interrupted at regular intervals by the moving parts. When the track empties because of jamming or depletion of parts, the beam stays unbroken long enough to actuate a control relay, which in turn shuts down the assembly machine until the jam has been cleared or the feed hopper refilled.

Results: By providing automatic monitoring, Photoswitch Controls coordinate the operation of two independent machine functions, eliminating manual supervision and down-time due to machine damage.

In Photoswitch's wide variety of "ready-to-use" photoelectric controls, liquid level controls and electronic timers, you will find controls that meet your requirements exactly. So . . . for the best solution to your control problems, call on Photoswitch . . . first!

FREE — Important New Catalog

"Proved Answers to Successful Automation" is a brand new 20-page technical catalog, giving full specifications, application information and dimension drawings on 14 versatile ready-to-use Photoswitch Control Sets. You will find it an important reference manual in solving automatic control problems. Use coupon to get your copy.

SEND FOR YOUR COPY NOW

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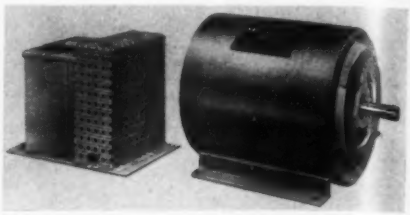
New Parts



a sheave on the crankshaft in front of the fan pulley, or it can be driven by a power take-off. The regulator is a static unit of the magnetic amplifier type with a selenium rectifier to provide alternator excitation. Windings of the regulator are encapsulated for protection against moisture and vibration. The regulator measures 10 x 6 x 7 in. Made by **Miehle Printing Press & Mfg. Co.,** Star-Kimble Motor Div., 200 Bloomfield Ave., Bloomfield, N. J.

Circle 112, Page 225, for more data

Aluminum Tubing 113

available in a variety of shapes and sizes

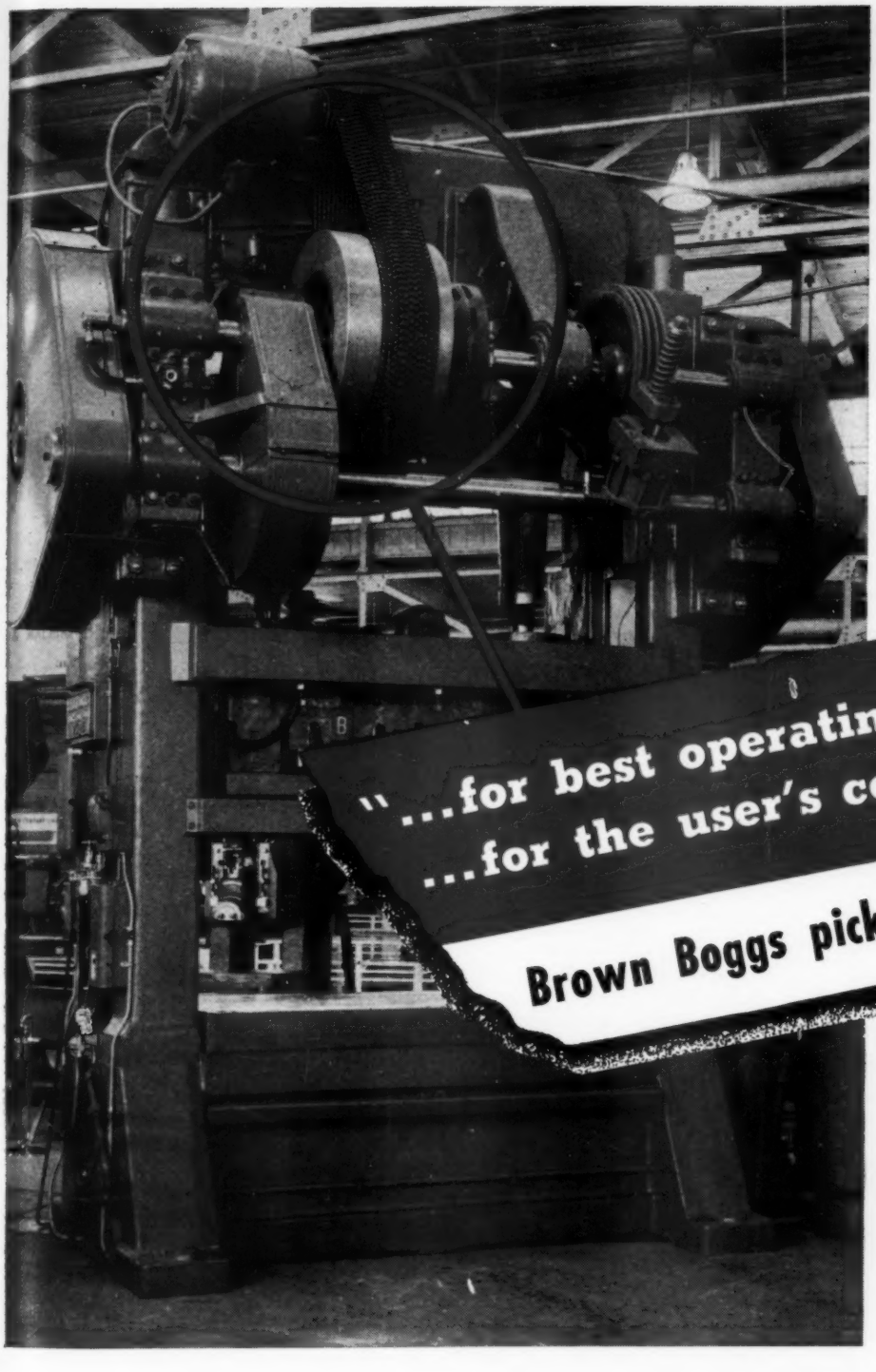
Made of Harvey 6066 aluminum alloy, a new high-strength tubing is highly corrosion resistant, has good surface finish and can be welded. It is made in square, rectangular or special shapes, as well as in the conventional round form, for applications such as in engines, refrigerators, appliances and unit heaters. Made by **Harvey Aluminum,** 19200 S. Western Ave., Torrance, Calif.

Circle 113, Page 225, for more data

Vibration Mountings 114

support loads to 2500 lb

Finnflex Floating Pillow vibration mountings, for medium and heavy machinery, support loads ranging from 500 to 2500 lb per mounting. The heavy-duty, high-deflection, rubber-in-shear type mounting design includes a pair of double deflection isolators that isolate vibration and also provide



"...for best operating condition ...for the user's convenience"*

Brown Boggs picked Veelos v-belt

The Brown Boggs Foundry & Machine Company, Ltd., of Hamilton, Canada, who manufactures this 200-ton Press, thoroughly checked all types of v-belt. They wanted a v-belt that would give efficient, vibrationless, full power delivery. They wanted a v-belt that could be installed quickly and easily. Only Veelos met *both* requirements. And here's what Brown Boggs says about their selection of Veelos . . .

**"We feel that our own factory assembly has put this Press in the best operating condition. To eliminate the necessity for dismantling any part of the equipment, and for the user's convenience in changing belts, we have equipped the drive with Veelos V-Belting."*

Brown Boggs selected Veelos even though it cost more than ordinary v-belt. They know, however, that "what's best for their customer, is best for their business!" It will pay you to equip your machines with Veelos v-belt. Once you've done that you'll be an enthusiastic Veelos user, too.

Veelos is known as Veelink in Canada and foreign countries.

VEELOS
THE LINK
V-BELT

Get the full story on Veelos... write today for your free copy of the VEELOS DATA BOOK.

MANHEIM MANUFACTURING & BELTING COMPANY
606 Manbel Street, Manheim, Penna.

ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE

2C88

New Parts

shock and overload control. The isolators are mounted at an angle between a semisteel base and cover. The metal parts enclose the rubber isolators, providing protection against damage. Overall height of the mounting is 3 in. Nonwalking, rubber-bottom baseplates eliminate the need for bolting the mountings to the floor. Made by **T. R. Finn & Co. Inc.**, Industrial Div., 200 Central Ave., Hawthorne, N. J.

Circle 114, Page 225, for more data

Integrator 115

ball and disk type has two independent outputs

Two integrator sections are driven by a common input in model 246 ball and disk type integrator. Output shaft speeds are independently adjusted by separate control rods. Input speed range is 0 to 150 rpm. Output speed for uni-

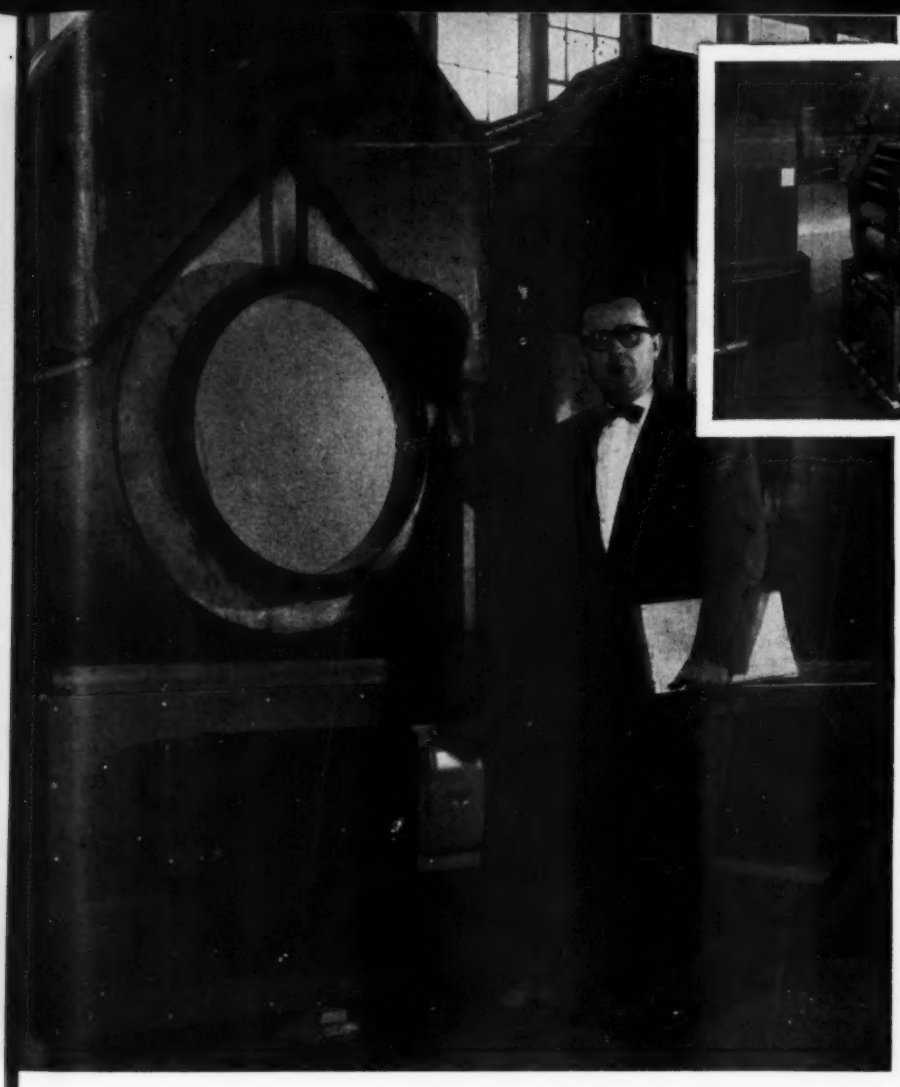
directional operation is 0 to 0.8 times input speed; for reversible operation it is 0 to 0.4 times input. Maximum output torque is 16 oz-in. Integrator operates with less than 0.5 per cent error. Housed in a 3 x 6 x 7-in. case, it weighs 7½ lb. Made by **Reflectone Corp.**, Myano Lane, Stamford, Conn.

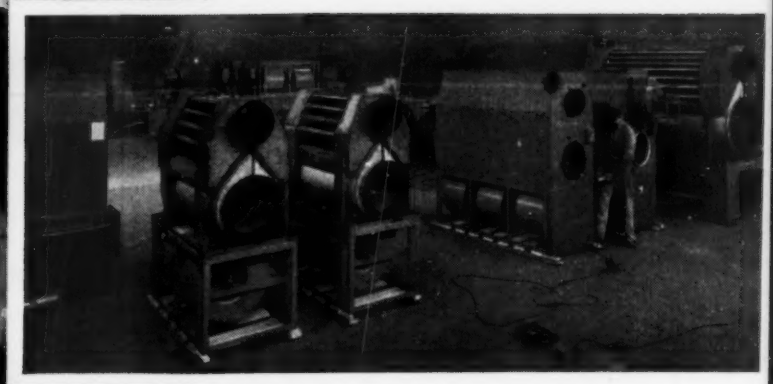
Circle 115, Page 225, for more data

Solenoid Valves 116

for sanitary or general industrial use

For applications that require sanitary operation, as well as for general industrial use, new floating seal solenoid valves operate with minimum pressure drop and with straight-through flow. Seals are 100 per cent efficient in either direction; the floating seal is self-cleaning and self-lapping. One

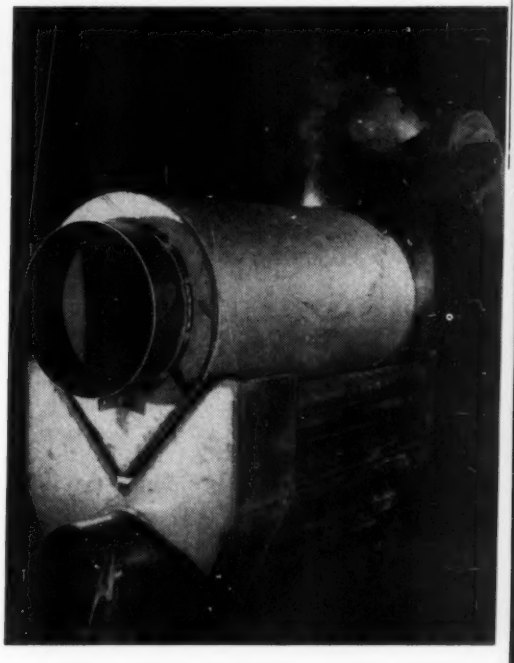




Final assembly of the heaters. Teardrop design of the firebox eliminates turbulence, permits entire surface to be wiped by air flow.

Mr. George Costello, Secretary-Treasurer, displays the Stainless Steel firebox for a National Heater.

Firebox is upside down for finish welding. Welders and other workers report no difficulty fabricating the Stainless Steel.



1945: Heater size reduced 25% with Stainless Steel

TODAY: *Increased unit efficiency—increased heater sales*

National Heater Company, St. Paul, Minn., has been making quality industrial heaters for 20 years. In 1945, they looked for a way to reduce the size of the units without reducing efficiency.

Primarily, it was a problem of moving the steel firebox walls closer to the flame. But carbon steel would eventually oxidize and lose its shape when brought too close to the flame. So they tried Stainless Steel, and it worked.

The new firebox was made from 14-gauge Stainless Steel. It retained its shape, strength and durability at the elevated temperature. It also eliminated the need for a refractory material.

The new firebox was 25% smaller than the old one. The Stainless Steel has given superb performance, and sales have increased.

There have been no fabricating problems. National Heater uses the same equipment for Stainless Steel that they use for carbon steel.

No other metal combines the corrosion resistance, strength, appearance and easy fabricating properties of Stainless Steel. Keep this remarkable metal in mind when you plan a new design – and for top quality, specify service-tested USS Stainless Steel.

See "THE UNITED STATES STEEL HOUR," Televised alternate weeks. Consult your newspaper for time and station.

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

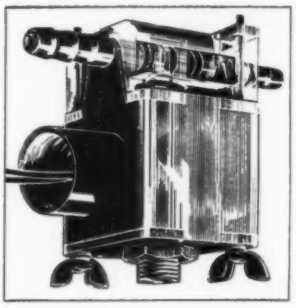
USS

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL

New Parts

valve, designed for completely sanitary operation, has neither blind holes, internal threads nor 90-deg angles. Other valves include a standard brass two-way model for



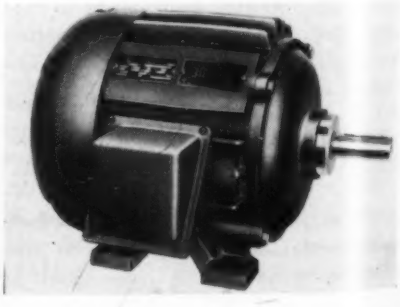
use with water, air and gases; a three-way brass valve, a flow diverter type and a four-way valve that has a single coil. Valves operate on 115 v, 60-cycle current at 10 w and at pressures to 125 psi. Made by **Valcor Engineering Corp.**, Carnegie Ave., Kenilworth, N. J.

Circle 116, Page 225, for more data

Enclosed Motors 117

available in ratings of 1 through 10 hp

These standard and explosion-proof totally enclosed motors have corrosion - resistant cast iron frames, improved winding insulation and heavy-duty ball bearings. Grease fittings at the top and bottom of the bearing housing facilitate lubrication and removal of grease. A running shaft seal on each end of fan-cooled motors and on the drive end of nonventilated motors prevents the entrance of moisture, dirt and other contaminants. Motors are currently available in ratings 1 through 10 hp, four-pole, 60 cycles in rerated NEMA frames 182 through 256U. Frames 213 and larger are cast with heavy ribs for efficient cooling. An external fan of bronze or



New Parts

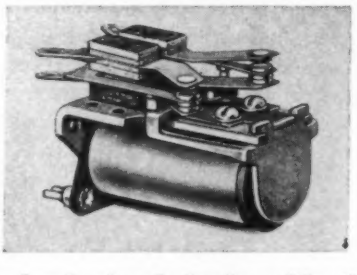
malleable iron cools the motor and prevents dust from collecting on the frame. Air flow is directed around all sides of the motor by a protective cast iron shield. Made by **Wagner Electric Corp.**, 6400 Plymouth Ave., St. Louis 14, Mo.

Circle 117, Page 225, for more data

Miniature Relay 118

handles heavy and low-level loads

Switching of heavy currents up to 10 amp and high operating sensitivity are combined in this miniature power relay. Heavy current contacts can be furnished in combination with bifurcated contacts for switching both heavy loads and



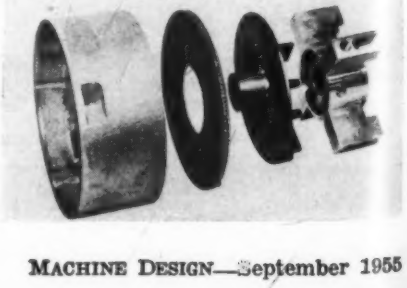
low-level signal loads with the same relay. Coil and contact terminals at mounting end facilitate concealed wiring of individually mounted or strip-mounted relays. Combinations up to four-pole, double-throw can be furnished with hermetically sealed or dust-tight enclosures. Relay is available for up to 440 v, 60-cycle ac or 230 v dc. Made by **Magnecraft Electric Co.**, 3350T W. Grand Ave., Chicago 51, Ill.

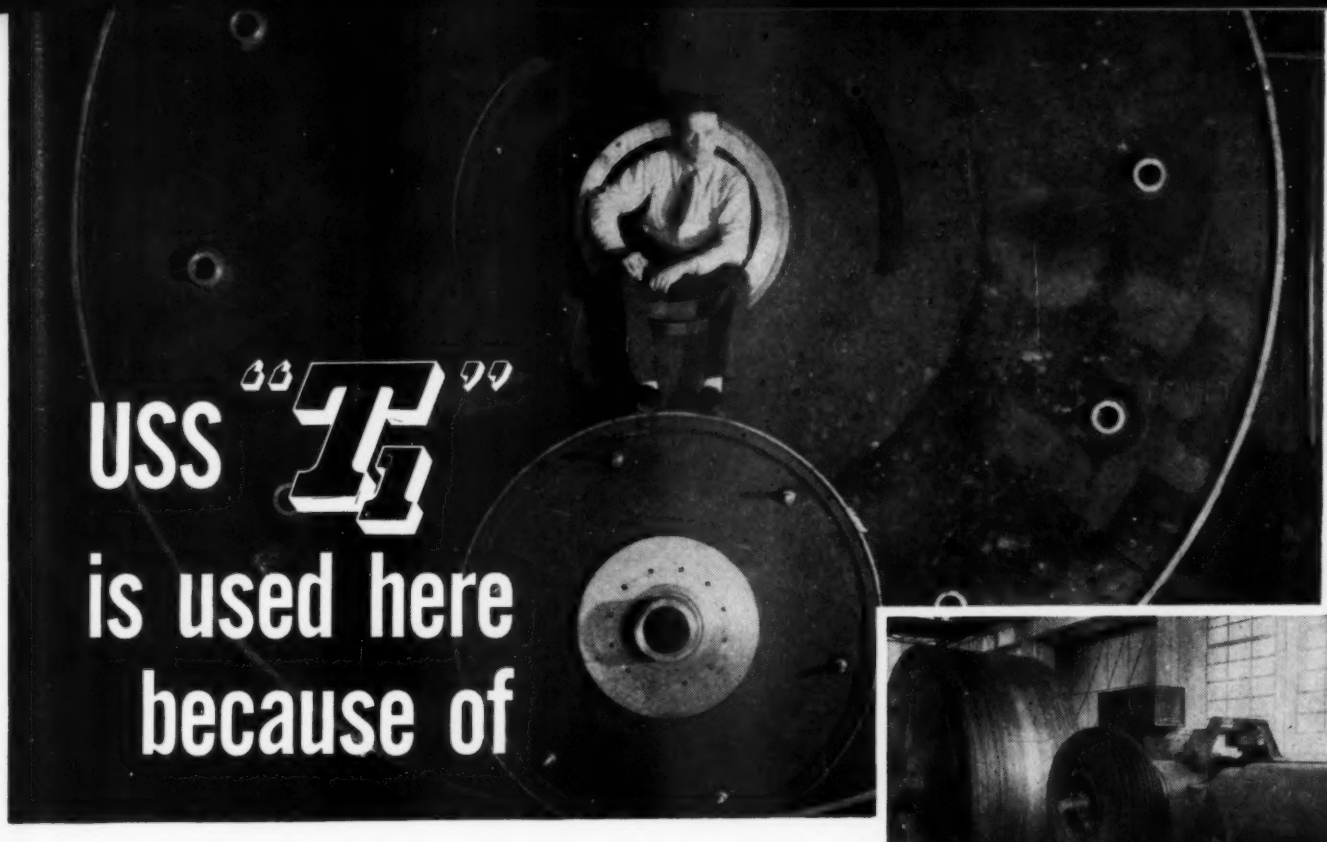
Circle 118, Page 225, for more data

Motor Brake 119

is built into motor frame

Completely mechanical in action, this motor brake is built into the motor frame and is enclosed in the housing for compactness. It allows





USS "T-1" is used here because of

'ROUND AND 'ROUND the flywheel goes, at a speed of 300 mph. Suddenly, an aircraft wheel assembly rams against it, with the impact of a loaded airplane. The tire squeals, the brake is applied, and in just 20 seconds the wheel stops. A real rugged test—both for the wheel assembly and for the steel in the flywheel. USS "T-1" Steel passed the test. In fact it is the best steel that could be used for this high speed application.

...its great strength

...its ease of fabrication

High speed tire, brake, and wheel testing machines like the one shown here, manufactured by Adamson United Company, Akron, Ohio, a subsidiary of United Engineering and Foundry Co., are used to prove out aircraft landing gear. The gigantic flywheels on these machines simulate the speed and inertia of an actual airplane during landing and take-off.

Until a short time ago, testing machines were built to rotate at peripheral speeds up to 250 mph. But when the aircraft industry spread its wings, faster testing machines were needed. The new machines had to rotate at speeds as high as 300 mph—and stay in one piece. They had to be extremely strong . . . lightweight . . . and easy to fabricate.

That's when USS "T-1" Steel entered the picture.

For flywheels rotating 300 mph, a steel of extremely high tensile strength was needed to withstand the tremendous stresses generated. A steel permitting the greatest strength for the thinnest section was needed. And, above all, the steel had to be capable of developing full 100% weld strength.

USS "T-1" Steel more than met all Adamson United's requirements.

Other steels could have provided the strength and met the weight requirements. None but "T-1" provided these and good weldability too.

UNIQUE PROPERTIES—"T-1" Steel's unique combination of physical properties has solved many similar problems. "T-1" can be welded satisfactorily *without* pre- or post-heating —it can be welded either in the shop or field. Always, it provides great tensile strength (105,000 psi minimum with yield strength of 90,000 psi minimum), phenomenal toughness and excellent abrasion resistance. Write for full particulars. United States Steel, Room 4905, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS

UNITED STATES STEEL

New Parts

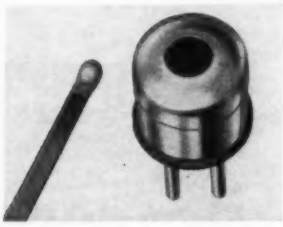
for quick opening and avoids sudden impact on stopping. Tension springs can be adjusted for rapid or slower stops. Brake permits smooth acceleration from standstill to full load, and it can also be inched. It operates in any position. Made by **Cleveland Electric Motor Co.**, 5213 Chester Ave., Cleveland 3, O.

Circle 119, Page 225, for more data

Heat Detector Cell 120

for remote application

Servotherm Thermistor heat detector cell type 1317 is a remote detector of far infrared energy for use in noncontact heat detection, measuring and control systems. It contains both active and compensating flakes. Six standard flake sizes are available, as are special



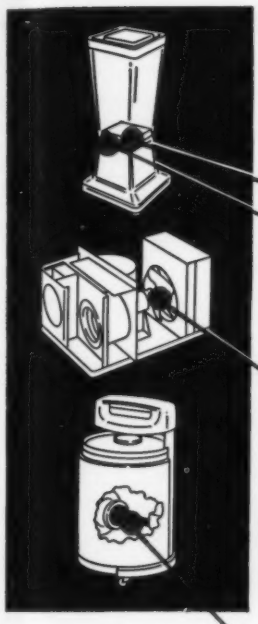
sizes and configurations. For a 1 x 1-mm active flake, resistance at 25 C is 3 megohms, operating bias is plus 80 v, time constant is 12 milliseconds, spectral response is 1 to 12 microns with standard Servofrax window or 1 to 25 microns with other windows. Made by **Servo Corp. of America**, 2020 Jericho Turnpike, New Hyde Park, N. Y.

Circle 120, Page 225, for more data

Precision Balls 121

are made of synthetic sapphire in 11 sizes

Precision balls of synthetic sapphire are stocked in 11 standard sizes from 1/64 to 3/8-in., including a 1-mm size. Balls offer excellent corrosion resistance, high abrasion resistance and extreme hardness. They are good electrical insulators. Compressive strength is 300,000 psi, water absorption is zero, and specific gravity is 3.98. All balls are made to tolerances of ± 0.0001 - in. on size and ± 0.000025-in. on sphericity. Sur-



LORD FACTS ON VIBRATION . . .

YOUR PRODUCT NEEDS "silent salesmen"

Solve your vibration and shock problems in the design stage, and you will give your product the advantages of "SILENT SALESMEN" for better performance and greater customer acceptance.

LORD Bonded-Rubber Mountings have gained wide acceptance for effectively reducing vibration and shock forces on all types of products. You will discover new design and performance advantages made possible through the use of these outstanding units. LORD has the experience and know-how to serve you best in this important field.

Equally important are the *SERVICES* and *SKILLS* available to you at LORD . . . ready to tackle your vibration problems. Experienced engineers and skilled workmen form the team that will help to improve the sales appeal of your product.

Your local LORD Field Engineer is as near as your telephone. Call or write the home office, Erie, Pa.

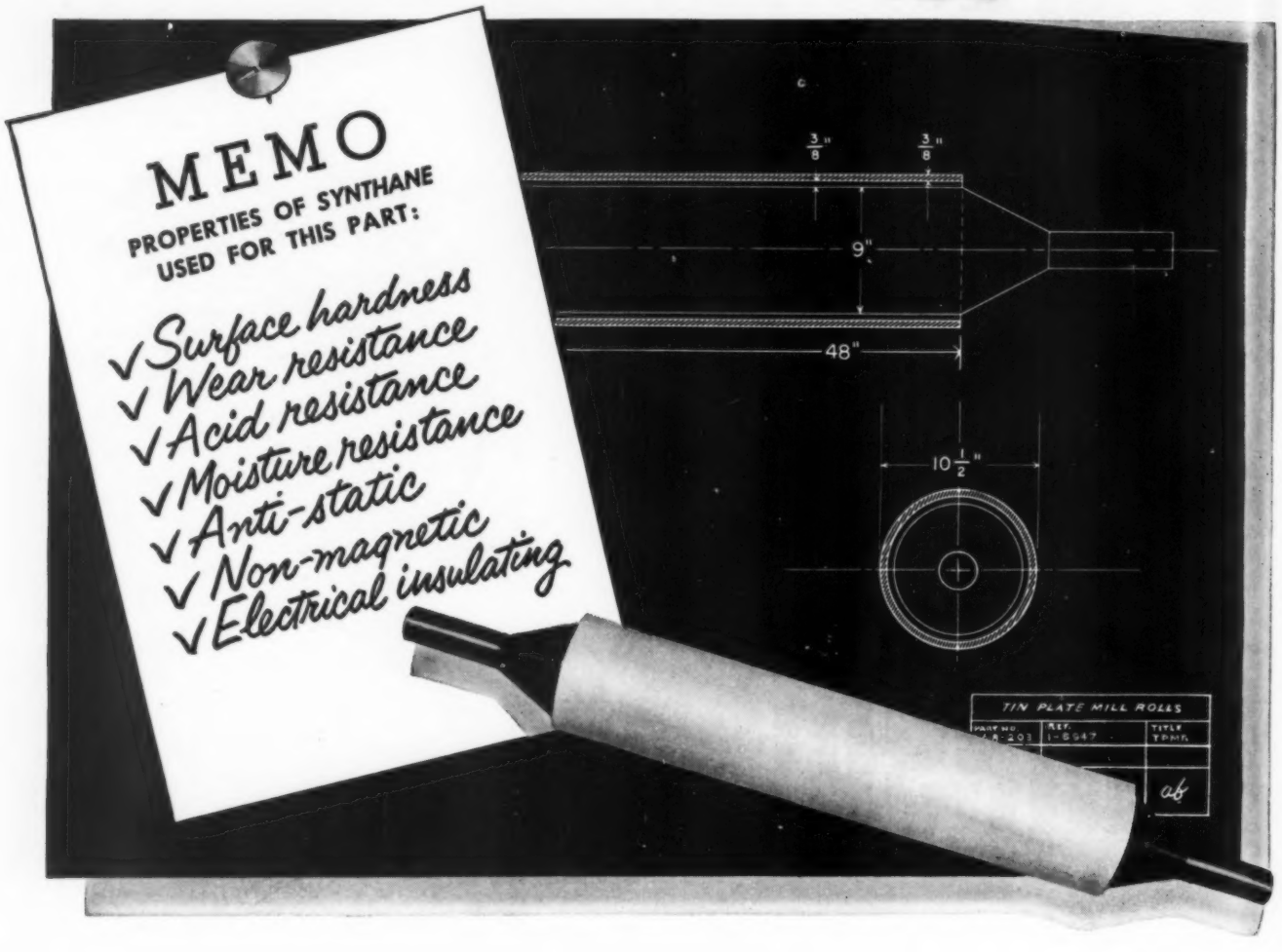
LORD MANUFACTURING COMPANY • ERIE, PENNSYLVANIA

LOS ANGELES, CAL. HOllywood 4-7593	DALLAS, TEXAS RIverside 3392	DETROIT, MICH. TRinity 4-2060	NEW YORK, N. Y. CIrcle 7-3326
PHILADELPHIA, PENNA. LOcust 4-0147	DAYTON, OHIO MIchigan 8871	CHICAGO, ILL. MIchigan 2-6010	CLEVELAND, OHIO SUperior 1-3242

LORD
BONDED RUBBER

DESIGNERS AND PRODUCERS OF BONDED RUBBER PRODUCTS SINCE 1924

YOU FURNISH THE PRINT, WE'LL FURNISH THE PART



TIN PLATE MILL ROLLS, COVERED WITH SYNTHANE LAMINATED PLASTICS, LAST 3 TO 5 TIMES LONGER, CUT DOWN TIME, IMPROVE PRODUCTION

The hundreds of rolls guiding steel plate through pickling, tin-plating and polishing operations at speeds up to 4100 feet per minute take a terrific beating from moisture, acid, sharp edges. Rubber-coated rolls sometimes last but a week. And tiny bits of abraded rubber prevent the deposition of the tin plate, mar the surface. Then Synthane laminated plastic covers were applied directly to the rolls.

What a difference! The hard Synthane surface does not become imbedded with foreign particles. Synthane is anti-static and non-magnetic, doesn't attract metal chips which could scratch the surface.

Synthane is also chemical-resistant; plating acids have little effect upon it, and being an electrical insulator, Synthane does not short the electroplating currents.

The net result is a 3 to 5 times longer life for Synthane-covered rolls, far less downtime; less maintenance and higher production rates. Look into Synthane's combination of properties for your product or application. Write for booklet of Synthane sheets, rods, tubes and fabricating service.

SYNTHANE CORPORATION, 5 River Rd., Oaks, Pa.

Please send me more information about the combination of Synthane properties.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

SYNTHANE

LAMINATED PLASTICS

SYNTHANE CORPORATION • OAKS, PENNSYLVANIA

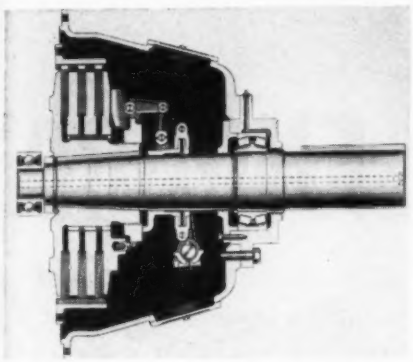
face roughness is less than 1 microinch. Made by **Industrial Tectonics, Inc.**, Jackson Rd., Ann Arbor, Mich.

Circle 121, Page 225, for more data

Power Take-Off 122

withstands excessive heat in 350-375-hp, 1800-rpm engines

Triple drive-plate construction of this heavy-duty power take-off provides ample friction surfaces to withstand excessive heat. It is engineered to meet requirements of engines in the 350 to 375-hp, 1800 rpm range. The power take-off accommodates an SAE No. 0 flywheel



and has a pilot bearing composed of a single row of balls operating in bearing races of double-row width. Spherical bearings used permit angularity, thus making the unit resistant to overload or destructive forces from heavy loads. Made by **Twin Disc Clutch Co.**, 1328 Racine St., Racine, Wis.

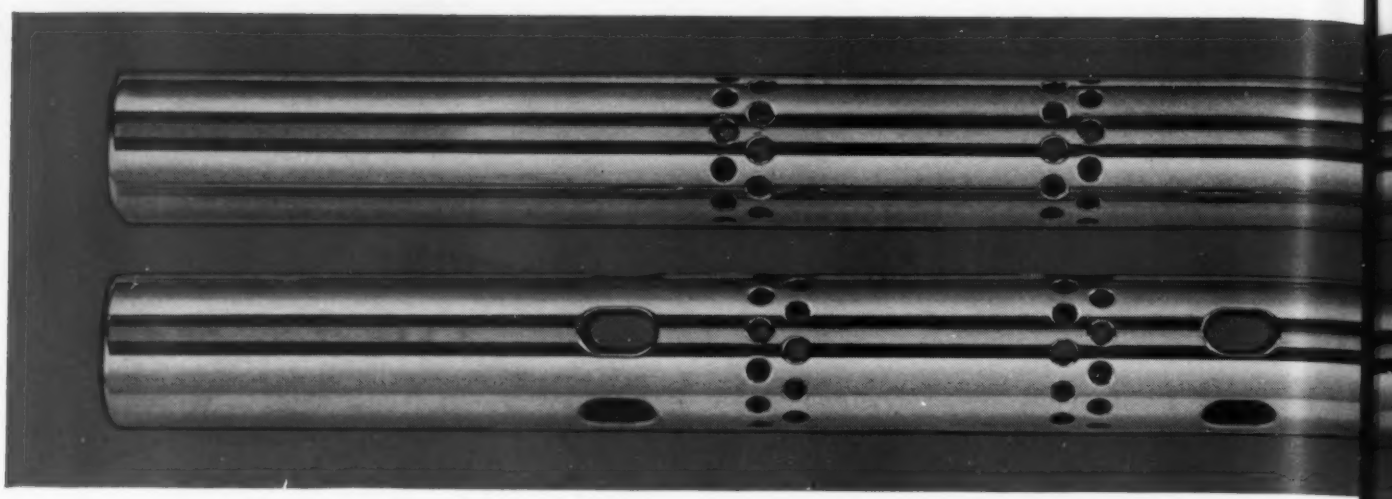
Circle 122, Page 225, for more data

Photoconductive Cell 123

spectral response ranges from 3500 to 5500 angstroms

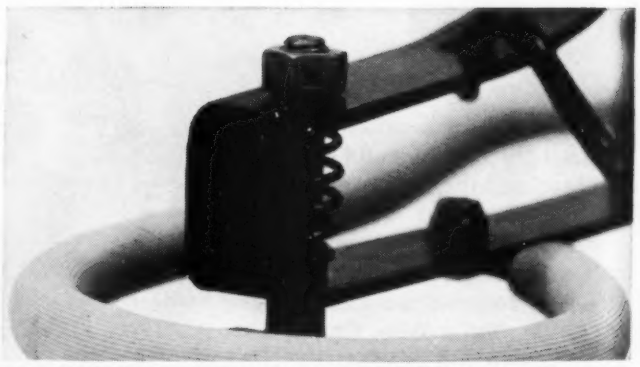
The tiny, head-on type 6694 cadmium-sulfide photoconductive cell operates with high luminous sensitivity, very low dark current and extremely low background noise. Signal output is directly proportional to the incident light intensity. Cell characteristics are not substantially affected by a wide change in operating temperature. Applications of the cell are in light applications requiring a single tiny photosensitive device, in light-controlled relay applications and in

(*Continued on Page* 290)



Free-machining ENDURO®

CONTROL MACHINING COSTS on mass-produced steel parts with Republic Hot Rolled Carbon Special Sections. These automobile door hinges were actually produced at less cost because much of the machining was eliminated. The special sections from which the component parts were made conformed to the predominating cross section of the part. Parts were cold formed by broaching. Tapping and drilling were the only other machining operations necessary. Republic supplies hot-rolled special sections in carbon, alloy and stainless steels.



CONTROL TENSION AND VIBRATION with Republic "Nylok" Nuts. They assure positive locking even under severe shock, vibration and tension. Here they are used to provide positive adjustment of spring compression. "Nylok" Nuts speed assembly, too. There's no fumbling to find the right side. Either end is up. Feed them automatically at full production speeds. Or manually for piecework. No special tools, lubricants or techniques are needed. They can be backed off for inspection and maintenance of parts and then can be re-used.

REPUBLIC STEEL CORPORATION
3130 East 45th Street,
Cleveland 27, Ohio

REPUBLIC STEEL

Please send more information on:

- ☐ Free-Machining ENDURO®
- ☐ Hot-Rolled Special Sections
- ☐ High-Strength Steels
- ☐ Republic "Nylok" Nuts

Name_____

Company_____

Address_____

City_____ Zone____ State_____

K-8124A

CONTROL EXCESS WEIGHT with Republic High-Strength Steels. When mobile equipment like earth movers, railroad cars, truck and gasoline trailers are designed and engineered from the beginning to take full advantage of the high strength and low weight of Republic High-Strength Steel, you can cut weight up to 50%. Corrosion-resistant qualities mean longer life for equipment, too. Republic High-Strength Steels are available in a wide range of sizes of sheets, plates and bars to meet your requirements.

helps control costs on highly machined stainless parts

These stainless steel plungers for pneumatic and hydraulic control valves require 30 separate machining operations in producing them. Costs could be expensive. But the manufacturer controls them by using Free-Machining ENDURO Stainless Steel Bars.

Republic's Union Drawn Division produces cold drawn bars with a fine surface finish, close tolerance, accuracy of section, uniform soundness for fast, economical production on highly machined parts like these. Free-Machining ENDURO provides the added strength and corrosion-resistance of stainless steel. Two grades, A.I.S.I. 416 and 430-F, are fully 90% as machinable as Bessemer Screw Stock.

Thus, you can apply the high physical properties and corrosion resistance of stainless steel to your duplicate steel parts—and still maintain economical, automatic production—by switching to Free-Machining ENDURO.

Republic ENDURO Stainless Steel is available in all forms, including hot rolled bars, special sections and wire. Republic metallurgists and engineers will give you expert assistance on applications, processing and use. Specify ENDURO on your next order for stainless steel bars. Mail the coupon for more information.

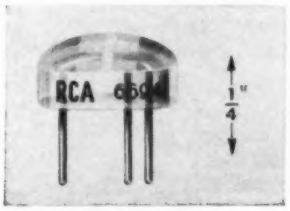
REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

New Parts

(*Continued from Page* 287)

computers. Spectral response covers the visible range from about 3500 to 5500 angstroms. Maximum response occurs at about 5000 angstroms. Maximum seated



length of the cell is 0.190-in.; maximum width and depth are 0.340 and 0.185-in., respectively. Minimum photosensitive area is 0.020 x 0.018-in. Made by **Radio Corp. of America,** Tube Div., Harrison, N. J.

Circle 123, Page 225, for more data

Potentiometer 124

operates at temperatures from −65 to 350 F

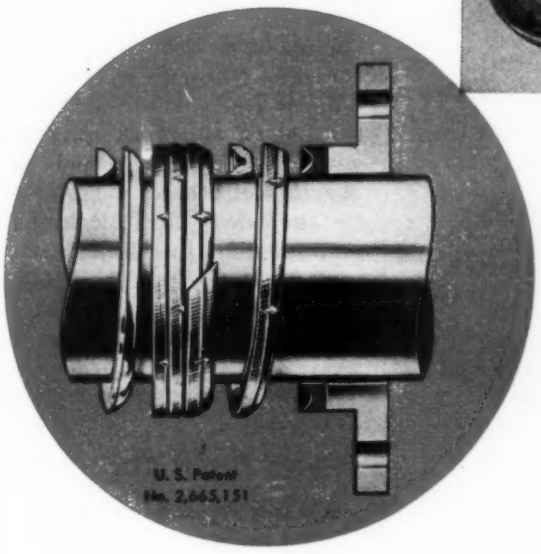
Model 160 Trimpot is a subminiature trimming potentiometer which operates in the temperature range of −65 to 350 F. Power rating is 0.6-w at 100 F and 0.4-w at 200 F. Resolution as low as 0.25-per cent is obtained over the 25-turn adjustment range. Resistance elements

provide excellent temperature coefficient characteristics in standard resistances from 10 to 10,000 ohms. Electrical settings are securely maintained during severe shock, vibration and acceleration. Shaft is self-locking. Instruments are splashproof, dustproof and corrosion resistant and can be mounted individually or in stacked assemblies. Side and end type mounting brackets for single or multiple mounting assemblies are available. Made by **Bourns Laboratories,** 6135 Magnolia Ave., Riverside, Calif.

Circle 124, Page 225, for more data

Really leakproof!

Linear VEE-DAM® rings



HERE'S A UNIQUE, revolutionary split V-Ring design that positively stops both labyrinth flow and lateral leakage!

LINEAR VEE-DAM RINGS don't require precise fitting. Even when gaps occur at the ring joints, through careless installation or variations in bore size, fluid can't leak past the rings. Here's why: *Sturdy Rubber Dams* (A) in the grooved hinge area hermetically seal off center groove sections. When rings are stacked together, these dams eliminate all labyrinth flow. *External abutments* (B) on the ring shoulders prevent lateral leakage and provide stabilizing support.

Let us show you how LINEAR VEE-DAM RINGS, engineered to your application in a choice of fabric reinforced synthetic rubbers, save you installation and maintenance time, and assure you absolutely leakproof packing over a wide temperature range.

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

ENGINEERING DEPARTMENT

EQUIPMENT

Pocket Slide Rule 125

5-in. model has eight scales

X-Act pocket slide rule has machine-divided precision graduations which are engraved with black and red scales. K, A, B, CI, C, D, S and T scales are included. Beveled leading edge of the rule incorporates 1/32-in. and millimeter scales. Smooth riding cursor with

chrome finish frame will not slip off the rule. Sine, sine and tangent and tangent scales, with hairline marker, are on the back of the rule, with the equivalent and setting chart. Fabricated of Divinyl plastic, the rule is dimensionally stable and resistant to oils and acids. It is 5 in. long, 5/32-in. thick and weighs less than 1 oz. Made by **Alvin & Co.**, Palisado Ave., Windsor, Conn.

Circle 125, Page 225, for more data

Printed Circuit Kits 126

various sizes are available

Designed primarily as an aid in prototype development, these printed circuit kits provide a means of processing etched-wire printed circuit models in industrial and research laboratories. By using the photographic method of resistor application, a pilot run can be made

with the materials provided in one of the kits. For development purposes, the application of resistors in the form of ink or in the form of a special pressure-sensitive 1/16-in. wide tape will permit frequent modifications during prototype design. An assortment of sizes of double as well as single-surfaced XXXP copper-clad phenolic laminate is provided, as are different types of special printed-circuit tube sockets. Special multiple-contact printed-circuit connectors are provided for applications where interchangeable circuitry is important. Available from **Techniques Inc.**, 135 Belmont St., Englewood, N. J.

Circle 126, Page 225, for more data

Oscilloscope 127

has 40 input channels

This large-screen oscilloscope provides a vertical line graph 9 in. high and 12 in. wide on a 17-in. cylindrical-face cathode ray tube. Each vertical line terminates in a dot to permit rapid and accurate reading. The output of each of the 40 amplifiers is scanned each ¼-second. The vertical length of

each line indicates the peak value of the maximum ac input voltage which existed during the previous ¼-second. A calibrated graticule is provided in front of the cathode ray tube for easy reading of voltage values and channel identification. Frequency response of each channel is within 2 per cent from 10 cps to 10 kc and down no more than 3 db at 50 kc. Each channel input is high-impedance, single-

(*Continued on Page* 299)

(*Continued from Page* 294)

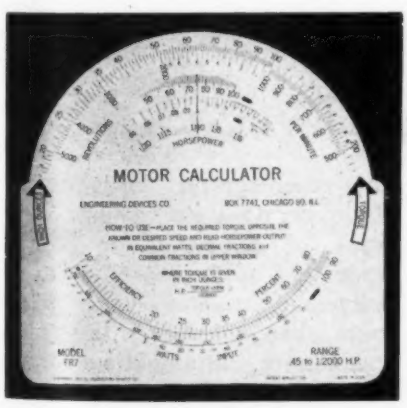
ended with one side grounded. The maximum sensitivity for each channel is 45 mv peak for full 9-in. vertical deflection. An X1, X/2, X/4 attenuator and a remote switch are provided for each channel. Sweep linearity is approximately 2 per cent with a system linearity of 1 per cent. Channel switching is accomplished by a motor-driven switch at a 0 to 20-v level. Made by **Electromec Inc.**, Oscilloscope Dept., 5121 San Fernando Rd., Los Angeles 39, Calif.

Circle 127, Page 225, for more data

Motor Calculator 128

covers horsepower range from 1/2000 to ½-hp

One setting of this FR7 direct-reading motor calculator, for any relationship of speed *vs.* torque, gives equivalent watts output and horsepower in decimal and common fractions, as well as the percentage of efficiency for any value



of watts input. This circular slide rule provides visual relationships between values. The calculator illustrated covers a horsepower range from 1/2000 to ½-hp; models for other ranges are available. Printed on vinylite, it is 6⅝ in. wide. Made by **Engineering Devices Co.**, P. O. Box 7741, Chicago 80, Ill.

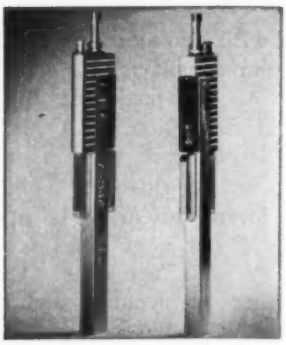
Circle 128, Page 225, for more data

Galvanometers 129

operate without amplifiers

High-Performance series galvanometers permit accurate recording of dynamic signals up to 200 cycles per second without amplifiers. Several are electrically interchange-

Engineering Equipment



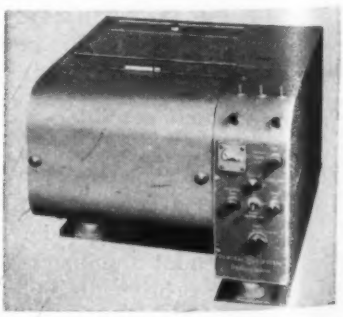
able with the present CEC 7-300 units, but have extended frequency response. Others in this series have extremely high sensitivity and are for use where maximum resolution or recording of very low level signals is required. Types are available for direct connection to commonly used 120, 180 and 350-ohm strain gages and resistance type pickups. Flat frequency ranges vary from 0 to 90 to 0 to 200 cycles per second. Made by **Consolidated Engineering Corp.**, 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle 129, Page 225, for more data

Oscillograph 130

records several variable factors simultaneously

This oscillograph, designed for static or dynamic testing of all types of industrial or aircraft equipment, will record up to 71 individual variables on one oscillogram when combined with suitable transducers and amplifiers for the measurement of such variable factors as pressure, vibration, strain and flow. A wide choice of galvanometers, usable up to 6000 cycles per second, provides flexibility of measurement. Two separate galvanometer mounts permit simultaneous use of both wound coil and bifilar galvanometers. The drive system employs two in-



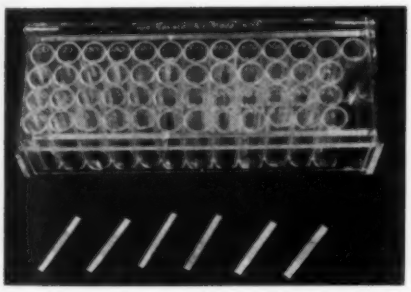
terchangeable idler gears to provide a speed range of 4 to 500 fpm. An automatic shutter closes as the 100-ft record holder is released from the oscillograph, reducing the possibility of fogging records during transportation. Models are available for operation on dc or ac. Made by **General Electric Co.**, Instrument Dept., Lynn, Mass..

Circle 130, Page 225, for more data

Tape Resistor Kit 131

contains a wide range of type RNP resistors

Designed for use in experimental or development work involving the use of tape resistors, the type RNP-1C kit includes ten each of the 49 standard MIL-R-11A values from 100 ohms to 1 megohm, inclusive, in ±10 per cent tolerance.



The kit is packaged in a compartmented case of heavy gage polystyrene plastic measuring 7⅛ x 3 x 1¾ in. The hinged top is etched to show the various values of the resistors, facilitating identification of each type RNP value. Available from **Hansen Electronics**, 7117 Santa Monica Blvd., Los Angeles 46, Calif.

Circle 131, Page 225, for more data

Pressure Transducers 132

have unbonded strain gages

Series of miniature pressure transducers is available in three types for the measurement of absolute, differential and gage pressures. They have high natural frequencies and are relatively insensitive to static or vibratory accelerations along any axis. No expoxy resins are employed as pressure seals, and the surface of the sensing diaphragm is homogeneous. Ther-

(*Continued on Page* 306)

Get the Drive

Tailored to Your Speed

A-C package drive, Size 5, 125 hp. Reversing, dynamic braking (rear view).

Size 2 packaged drive, 25 hp, with electronic speed regulation ¼ of 1% based on top speed, 3550/50 rpm.

A-C ALLIS-CHALMERS

ALLIS-

Control Needs

ALLIS-CHALMERS Package Drive Gives You

- ★ Wide speed range
- ★ Precise speed control
- ★ Operation from one or more points
- ★ Simple installation
- ★ Reduced maintenance

If you need speed control for up to 200 total horsepower plus special performance characteristics such as threading, jogging, dynamic braking, etc., the Allis-Chalmers package drive will provide these functions in one easy-to-specify unit. The package drive itself consists of a motor-generator set and control components mounted in a well-ventilated cabinet. Control stations and dc drive motors may be placed wherever convenient. Installation is simple because the unit is factory-wired and ready to operate. Maintenance is reduced because cabinet keeps equipment clean and out of harm's way. All three of the basic components — m-g set, control and drive motors — are designed to operate as a unit.

Engineering Assistance

Allis-Chalmers application engineers are thoroughly familiar with OEM problems and will be glad to help you at every stage of your operation. For help, call your nearby Allis-Chalmers District Office. For literature, write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 51B8166. A-4620

Vari-Pitch is an Allis-Chalmers trademark

Other Allis-Chalmers Speed Control Drives

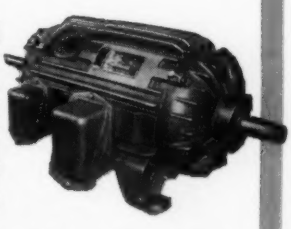
Mechanical

Where a moderate speed range is required and where the machine may be stopped to make required speed changes. Horsepower range — 1½ to 300. Speed adjustment range — 9 to 28 percent. Two *Vari-Pitch* sheaves used together double range of adjustment.

Mechanical

Where speed must be changed while machine is in motion. Particularly good for machines requiring fine adjustment while operating. Double range of adjustment may be obtained by using two *Vari-Pitch* sheaves. Horsepower range—1½ to 600. Speed adjustment range —9 to 28 percent with one *Vari-Pitch* sheave.

Electrical



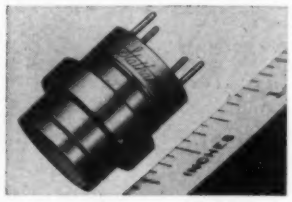
Where stepped speed control is satisfactory. Available with stepless control in larger sizes by using liquid rheostat. Speed is varied by means of control on secondary windings of motor. Horsepower range — 5 hp and up. Speed adjustment range — 30 to 96 percent of synchronous speed for fan duty.

CHALMERS

Engineering Equipment

(*Continued from Page* 303)

mal zero shift is not more than 0.01-per cent full scale per deg F; the change in sensitivity is not more than 0.01-per cent per deg F over the temperature interval of −65 to 250 F. At 5 v excitation dc or ac the full scale open circuit output is 20 mv. The total effect



of nonlinearity plus hysteresis is less than ±1 per cent of full scale. The sensing diaphragm may be exposed directly to the pressure media in applications requiring flush mounting, or interchangeable adapters are available to convert the basic instrument into a chamber type pressure transducer. Made by **Statham Laboratories Inc.,** 12401 W. Olympic Blvd., Los Angeles 65, Calif.

Circle 132, Page 225, for more data

Book Photocopier 133

reproduces pages of books and magazines

Floating lid of this model HT-1 flat bed printing machine provides up to 1½-in. clearance between lid and platen for insertion of books, magazines and other bound material for reproduction by photocopy technique. It can also reprint from single sheets as well as thick cardboard. Copies of anything written, typed, printed or drawn can be made in 1 minute, using dry transfer photocopy materials. It can also be used with conventional wet process materials. Made by **Hunter Photo Copyist Inc.,** 595 Spencer St., Syracuse, N. Y.

Circle 133, Page 225, for more data

DESIGNING WITH ALUMINUM

NO. 15

ALUMINUM vs. STEEL STRUCTURALS

THE light weight, strength and corrosion resistance of aluminum alloys are causing them to be increasingly considered for applications where structural steel has been the traditional material of construction.

Aluminum weighs about 0.10 lb. per cubic inch, structural steel about 0.28, or nearly three times more. Aluminum structures weigh from 35% to 70% of their steel counterparts, which suggests a number of economic advantages to be gained through the use of aluminum:

1. Ease of handling light sections in the fabricating shop.
2. Reduced shipping and erection weight—hence, the possibility for greater off-site fabrication.
3. Reduced erection time with attendant reduction of construction costs and earlier placement of the structure in service.

It also points up applications wherein the fullest advantage of weight reduction is to be gained:

1. Long-span structures in which the greatest load is the weight of the structure itself.
2. Structures whose component parts must be shipped long distances and erected in difficult-to-reach locations.
3. Structures which are difficult to erect or which must be erected without the aid of heavy lifting equipment.
4. Structures in which demountability or portability is a requirement.
5. Mobile structures which impose a dynamic load on their supports and may have power requirements.
6. Structures located in areas where expensive foundations are required.
7. Applications which impose additional loads on existing structure.

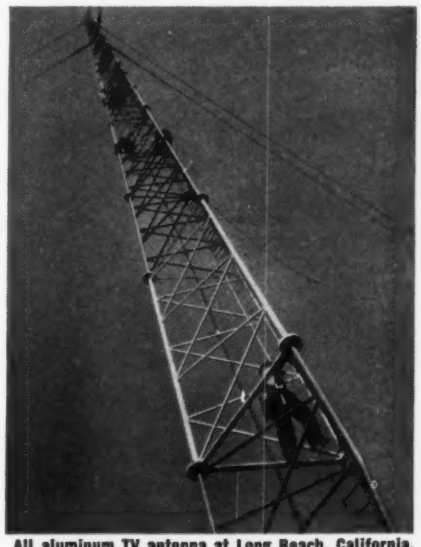
Aluminum alloys are highly resistant to atmospheric corrosion. No surface treatment is required for most of the alloys used in structural applications. This is an obvious advantage over structural steel which must be initially protected by galvanizing or painting, and periodically repainted during the lifetime of the structure.

Corrosion resistance therefore suggests additional economies, beyond those found in weight savings, for aluminum structural applications:

1. Exposed structures, particularly those located in industrial atmospheres and areas of high humidity.
2. Structures which are expensive to repaint because of location or intricacy of detail.
3. Structures which must be taken out of service to allow maintenance.
4. Structures composed of light members in which arbitrary corrosion allowances determine the minimum thickness of steel members permissible in the design.
5. Applications in which an attractive, permanent finish is required.

Well-designed aluminum structures weigh considerably less than similar steel structures. This is due not only to aluminum's low density in relation to steel, but also to the strength and elastic properties of the aluminum alloys. Figure I lists certain of the typical and minimum tensile properties of several of the aluminum alloys commonly used in structural applications, and those of structural steel.

It will be observed that the tensile yield strength of alloy 6061-T6 compares with the yield of structural steel while the ultimate tensile strength of alloy 2014-T6 is the same as the ultimate of steel. Since permanent deformations in a structure caused by stresses in excess of the yield strength of the material are generally considered undesirable, design working stresses are usually selected by applying a suitable factor of safety to yield strength. On the basis of yield strength, then, a 6061-T6 tension member would carry the same load as an identical structural steel member and weigh less than ⅓ the steel member.



All aluminum TV antenna at Long Beach, California. Prefabricated in approximately 20-foot sections.

Some designers apply a somewhat greater factor of safety to the tensile yield strength of the aluminum alloys than to that of steel because of the difference in spread between yield and ultimate. It is important to note that even if the same safety factor were applied to the minimum ultimate tensile strength of 6061-T6 and structural steel, the 6061-T6 member would weigh less than half that of a steel member carrying an equivalent tensile load. In addition, the aluminum member would provide a greater margin of safety against permanent deformation.

FIGURE 1

		Typical Tensile Properties			Minimum Tensile Properties		
Metal	Alloy and Temper	Yield Strength PSI	Ultimate Strength PSI	Elongation % in 2"	Yield Strength PSI	Ultimate Strength PSI	Elongation % in 2"
Al.	2014-T6*	65,000	71,000	10	55,000	60,000	7
Al.	5083-O†	22,000	44,000	21	18,000	40,000	16
Al.	5083-H112§				24,000	40,000	12
Al.	5083-H113†	33,000	46,000	16	31,000	44,000	12
Al.	5086-O†	17,000	38,000	22	14,000	35,000	18
Al.	5086-H112†	19,000	39,000	14	18,000	36,000	8
Al.	6061-T6	40,000	45,000	17	35,000	38,000	10
Al.	6063-T5	25,000	30,000	12	16,000	22,000	8
Al.	6063-T6	30,000	35,000	12	25,000	32,000	8
Steel	ASTM-A7	38,000	60–72,000	30	33,000	60,000	24

*Fusion welding of 2014 not recommended. †Plate properties.
§As extruded. Typical mechanical properties vary according to size and shape of structural sections.

PLEASE TURN TO NEXT PAGE

In many cases, the stiffness of a structural member is the governing factor in design and stiffness is a function of the modulus of elasticity of the material of construction. The modulus of elasticity of the aluminum alloys is about 10,300,000 PSI while that of structural steel is 29,000,000 PSI. Hence, it will be seen that an aluminum beam will deflect the same amount under its own weight as an identical steel beam, since the aluminum beam will weigh but ⅓ the steel beam. Under the same applied load, the aluminum beam will deflect up to almost three times that of the identical steel beam depending upon the relation of dead load to total load.

If, under the same conditions of loading, stiffness equal to steel is required of an aluminum beam, it can be achieved—with substantial savings in weight—by selecting an aluminum beam having increased section properties. For example, a 7" aluminum I-beam weighing 5.42 lbs. per foot has three times the moment of inertia of a 5" steel I-beam weighing 10.0 lbs. per foot, nearly twice as much. Thus, equal stiffness is provided and stresses due to bending in the aluminum beam will be less than half those in the steel member.

To take full advantage of the high strength of the aluminum alloys, deflection criteria should be closely examined to make certain that the design is not needlessly penalized by arbitrary and unnecessarily severe deflection limitations. Reducing deflection through the use of rigid framing and continuity should not be overlooked. The maximum deflection of a uniformly loaded, continuous beam of two equal spans is less than half that of a simply supported beam if unsupported length, loading and beam section properties are equal.

The elastic modulus also affects the stability of compression elements. For example, the load to cause elastic instability of an axially loaded slender column is directly proportional to the modulus of elasticity of the metal used. Hence, an aluminum column will carry but ⅓ the load of an identical steel column, but will weigh only ⅓ as much as the steel column. By selecting a somewhat heavier aluminum section, it is possible to support a load equal to that of the steel column with substantial weight reduction. For example, an 8" x 8" wide flange aluminum column will support about one-half again as great an axial load as an 8" x 5" wide flange steel column of the same length before becoming elastically unstable. Yet, the aluminum member weighs 11 lbs. per L.F., the smaller steel section 20 lbs. per L.F.—nearly twice as much.

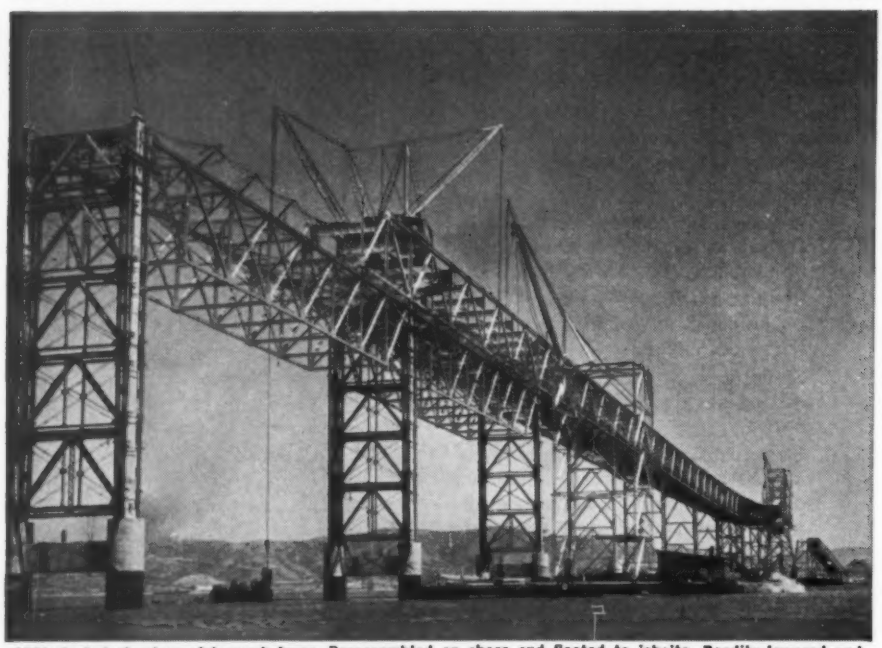
Aluminum's lower elastic modulus has a beneficial effect in absorbing impact loads and reducing stresses caused by inexact fit-up of members in a structure. Because of the lower modulus, stresses induced by temperature changes in restrained members are less for aluminum than for steel. This is in spite of the fact that the coefficient of thermal expansion of aluminum is about 0.000012 in/in/°F, or almost twice that of steel.

Procedures involved in the fabrication of aluminum and steel structures are comparable. As with steel, joining can be accomplished by riveting and bolting. Aluminum rivets and bolts are usually used in aluminum structures for maximum corrosion resistance. Either hot or cold driven aluminum rivets can be used. Holes for aluminum rivets and bolts in primary structural members are drilled or subpunched and reamed and aluminum members are sawed, sheared or cut with a router rather than flame cut.

Aluminum members can also be joined by welding. Allowable stresses across welds are reduced to offset a certain reduction in strength in the heat affected zone. Two new alloys, 5083 and 5086, recently developed by Kaiser Aluminum, show great promise for welded aluminum structural work. Inert-gas arc welds of these alloys in plate and sheet exhibit joint efficiencies varying from 80% to 100%, depending on the original temper of the base plate.

Hence, the use of standard aluminum structural shapes offers exciting possibilities to the designer in the development of efficient structural solutions. In addition, the extrusion process makes possible the economical production of special aluminum sections for unique design situations. Kaiser Aluminum engineers, experienced in the design of aluminum structures, will welcome the opportunity to assist you in designing with aluminum.

Contact the Kaiser Aluminum sales office listed in your telephone directory or one of our many distributors. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office:* Palmolive Building, 919 North Michigan Ave., Chicago 11, Illinois; *Executive Office:* 6977 Kaiser Building, Oakland 12, California.



285′ riveted aluminum falsework truss. Preassembled on shore and floated to jobsite. Readily lowered and moved between towers in its use as erection platform for construction of San Rafael-Richmond, California bridge. Weight 110 tons. Estimated weight in steel approximately 300 tons.

Stress Relief

ONE engineer's amusing but nonetheless significant commentary on the engineer shortage came to us the other day. He recorded in some detail the affairs in

An Engineer's Day

The boss says we have to beat the costs out of our developments. I feel fertile this morning. I should be able to wring the water out of that governor design. I'll work on the bearing. Before I do that, I guess I had better fill out my time sheets for the accounting department. Now let's see, where are those notes I kept? . . . Last Monday, ½-hour on development 265, 1½ hours on development 211. That makes 2 hours, now where did the other 6 hours go? I can't charge it to overhead; they don't like it. Where did they go? Oh yes, there was that shop difficulty in the morning, and the Cost Reduction meeting in the afternoon. That's charge 151. Gee! Tuesday, Wednesday, Thursday, and Friday are also pretty spotty. Well, I'll just have to remember, so here goes . . . It's nine o'clock. The sheets are all in. I did pretty good this week.

Now to get at that design. Oop! There goes the phone. Good morning! You want Mr. Ryder. He's busy right now in a meeting. Take a message? Okay, blah, blah, blah . . . Yes, I'll put a note on his desk pad.

If I put a brace under the tube for the bearing here. . . . Oh, oh, here comes that Cost Reduction guy. Good morning, how are you? Fine—yah, yah . . . How good is my memory? The meeting four months ago in May. Yes, I was there. What did we decide to do on revising the design to make it easy for Stock Control to keep a record of the parts? Now let's see. Oh yes, I remember . . . blah, blah, blah . . . Okay, don't mention it. Take it easy.

Cripes! It's a quarter to ten. Where was I? I'm going to put a strut under the bearing tube here. There isn't much room for a bearing. I wonder if I can use a needle bearing. I'd better get the manufacturer's catalog. The catalog hasn't been kept up for the last five months. No use looking in the rack. I wonder if Jack has it. He's always using needle

Stress Relief

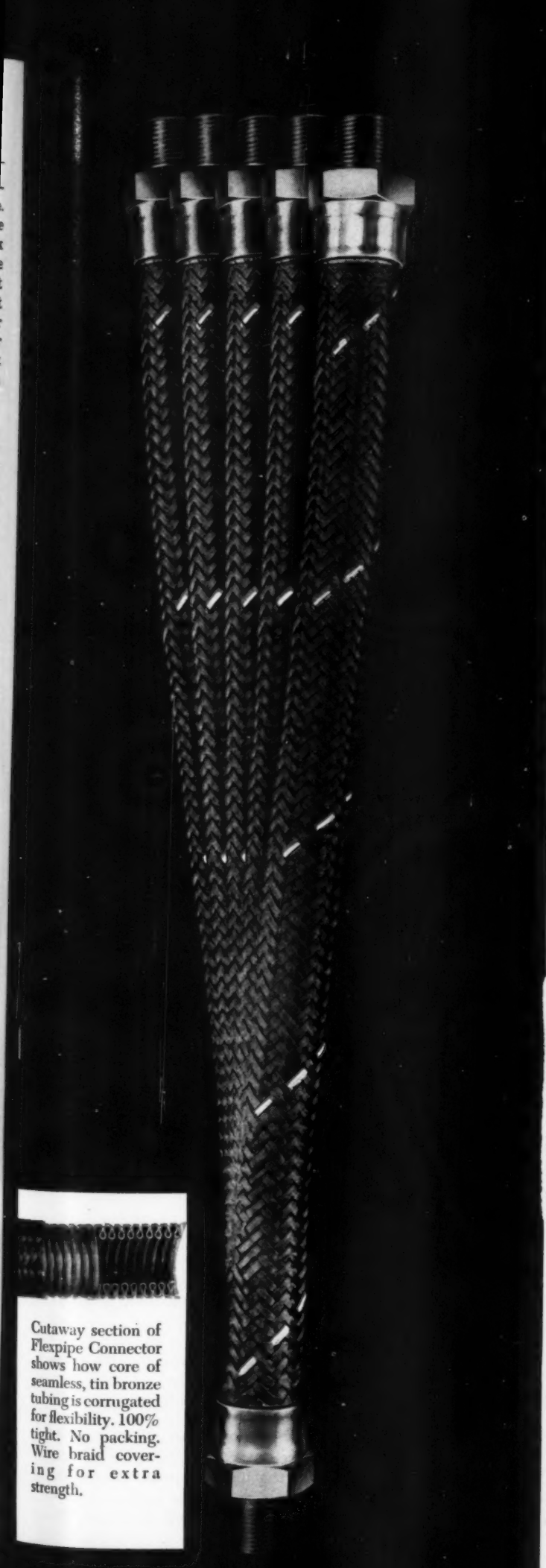
bearings. Say Joe, where's Jack? Upstairs? I'll call him on the phone. Geez! I don't know why Milt is sore because I disturbed him; I got work to do, too. If he's not there maybe he's with Mike. I'll go up and get him. Yeah, Jack, I'm at the point of figuring the bearing. It's under the pile of correspondence on your desk. You got it out but couldn't get to it. Okay, I'll put it back when I'm through. I'm sure glad I got it that easy.

Let's see, its 10:30. The morning mail is here . . . nothing impressive. Oh, oh! The binder people lost their sample of the cover for the Navy instruction book. This is a hot job. Should they chance the job on the basis of the layout? Better not. There are 70 binders involved at $8.50 each. I'll write BuShips and see if I can wheedle their sample back. Now, let's see, I need contract number, transmittal letter number, distribution of letter copies, etc. . . . Look at that pile of filing. It hasn't been done in two months. I worked on that three weeks ago. That ought to be about 4 inches down in the pile. We'll run through the pack. Ah! Here it is. Gee, I wonder when they're going to get a replacement for our steno. Mark's girl is tied up on an important job. What we need is two or three girls. Oh well, stop dreaming. I hate to write a letter by hand. It's actually double work. There's no alternative, so here goes . . . scratch, scratch, scratch . . .

Gee, I'm getting hungry; it's 11:15 already. I'll take this letter to Karen in the order department. Maybe if I ask her in a nice way and she's not busy with WH's work she'll type it for me. Remember, don't get excited if she refuses. It's important to keep the girls happy. Management is having trouble getting girls . . .

Boy, I'm glad that's done. Now to get started on—there goes that phone again. No, he's not here. Take a message . . . Okay . . . To get at that bearing. I'll have to figure this application pretty close. What's that shadow? Oh, Johnny. I didn't know you were standing there. You have a change in a drawing? Your supervisor isn't around, and you saw my name on a previous substitution. Would I take a look at the job? Okay . . . Now, I can't tell you to do it this way. It's in WW's hands to give the orders, but if it's to be done correctly, that's the way it must be done. Okay, don't mention it.

It's a quarter to twelve. Where did the morning go? Now let's see, the radial load is 600 lb, 100 rpm, speed factor 2, use factor . . . There goes the lunch bell. I'll mull it over



Cutaway section of Flexpipe Connector shows how core of seamless, tin bronze tubing is corrugated for flexibility. 100% tight. No packing. Wire braid covering for extra strength.

NOW... a new, standard *flexible* connector to save the cost of special design

FLEXPIPE* permits travel... absorbs vibration ...connects misaligned ports in pipe lines

Here's a new, *standard* tin bronze flexible connector you can use to convey air, gas, oil, steam or water. Flexpipe Connectors have standard plated brass pipe fittings at each end. They permit travel, flex with motion, and dampen vibration. They save time and materials by taking the place of rigid connections made up on the job with elbows, couplings and short runs of pipe. When intermittent travel occurs, Flexpipe Connectors move with the pipe, relieving stresses which shorten the life of rigid connections.

Flexpipe Connectors are designed for wet heating systems, and for trouble spots in commercial and industrial piping. Sizes, lengths, part numbers and operating pressures are given in the table below.

I.D.	Max. Offset each side of C/L (intermittent travel)	Over-all Length Inches	Part Numbers	Max. Working Pressure at Room Temp. PSI	Max. Working Pressure at Max. Temp. (350°F) PSI
¼	½ 1¼	8 16	¼ M-10 ¼ M-20	1200	850
⅜	½ 1¼	9 18	⅜ M-10 ⅜ M-20	1000	700
½	½ 1¼	10 20	½ M-10 ½ M-20	750	525
¾	½ 1¼	11 22	¾ M-10 ¾ M-20	600	425
1	½ 1¼	12 24	1 M-10 1 M-20	550	375
1¼	½ 1¼	13 26	1¼ M-10 1¼ M-20	300	200
1½	½ 1¼	14 28	1½ M-10 1½ M-20	275	175
2	½	18	2 M-10	200	125

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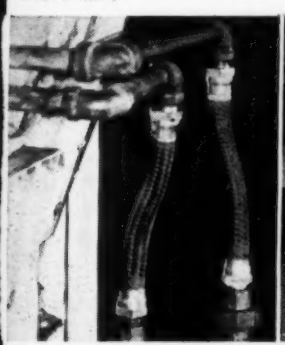

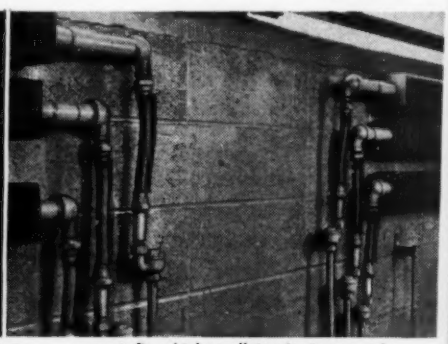

.. connects misaligned condensate drains ... connects finned tube radiators to steam supply

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The American Brass Co., American Metal Hose Div., Waterbury 20, Conn.
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COMPANY.....

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My Distributor's Name.....

City.....State.....

Stress Relief

during lunch.

Gee, this is pretty poor looking chow. Supposed to be goulash, looks like soup. Now that bearing. Can I save putting a shoulder on the bore by using a retaining ring? Hi, Joe. You say you're having trouble with your washing machine. The thing rumbles only on the dry spin. Do I know what's wrong with it? Well, let's see, the dry spin is a higher speed. There's a definite vibration? Must be near a critical. You say, if you put your hand on it, it stops. I'd suggest you change the mass or the spring constant a little bit. Don't mention it, see you around.

Back at the board. Gee, that support doesn't look too good. Oh well, with the pressure on I can't go back over it; I'll never get done. It may not be the best, but it won't fail. Now, let's see. Fits for a needle bearing are . . . I wonder when we'll get someone to answer the phone. You say you're down in the weld shop? The inspector won't pass the part but you think it's okay. Will I look at it? It's a loss of $500 if you scrap it? Well, I don't know. I shouldn't get into it unless it's absolutely necessary. . . .

Now, fits for the bearing? There goes that phone again! . . . You're the Navy inspector. You don't think the part is any good. The print shows full weld, but the note only calls for 2 inches of ⅜ weld, and the welder put on 2 inches. You can't pass it? For crying out loud! You don't go by the picture. It's the drafting information that counts. You won't pass it unless I send a letter to the head Navy inspector, copy to Newark. Okay, okay . . . goodbye. If I don't do it, they'll have everyone in the soup. I wonder if Mark's girl is still busy. I guess so. I'll write it by hand . . .

It's almost two o'clock. That goulash is back upstairs again. Ugh! Now let's see, diameter of shaft . . . I'll fit this in the layout. . . . 1.6200 from 3.1250 . . . What the heck is all that noise up front? This place is like Broadway and 42nd on Saturday night.

That was zero five zero two, or was it zero five zero one? Hello, Jake. What am I doing at three o'clock? There's a meeting on platform frames. Do you really need me? Someone has to answer the questions on design. Okay, I'll be there. Now, let's see, this wheel has to take our latest governor rope arrangement. I believe we're now using ½-inch steel rope as standard on the rest of the line. Where's the manual. I guess its across the hall. . . . Now, these sheets show iron on the instan-

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Today's product designer is well aware of the importance of quality in the components used in each piece of machinery he engineers.

SEALMASTER Ball Bearing Units assure maximum performance and their exclusive combination of features provide a decided competitive advantage for any machinery manufacturer. Four features you will find in no other bearing unit except SEALMASTER are shown at left and explained briefly below. These are features to insure greater performance for the products you build. They are features you will want to learn more about. Write for full information:

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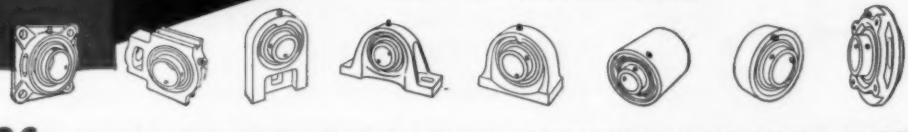
SEALMASTER BALL BEARING UNITS



SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 18 RIDGEWAY AVENUE, AURORA, ILLINOIS

Stress Relief

taneous governor and steel on the wedge type. Maybe there's a later sheet. . . . I never know if the books are up to date. Maybe I'd better go upstairs and look at the change-notice file. Gee it's two minutes to three. Better get to the meeting . . .

Look at all the "brass" here. They must have pretty competent help to take care of their business while they attend meetings. I wish I did. That bearing is still a problem with me. . . . What did you say? Do *I* know how many pieces of this frame we use per year? Let me see. We sell about 200 units per year and this platform design is used in 80 per cent of the line, and there's one frame per unit. That's about 160 bearings—I'm sorry—I mean frames per year. Don't mention it. With the governor sheaves at 18 inches diameter, a ½-inch rope is as large as we can go. A larger sheave would be better but I haven't the room. I'll have to look at the board again. Say this was supposed to be a meeting on design. Now they're squabbling over the layout problem in the shop. Maybe I can work out the governor wedge while I'm . . . How many of these things can we get into a rack 10 by 10? Well I don't know. Did anyone look at the blueprint? No I'm not being funny. Just like to be sure . . .

Boy I'm glad that meeting is over. I have a headache and I can still taste that stew. Only three lines added since this morning and its 4:45. Might as well waste the other 15 minutes. I'll go and get a dose of soda and see if I can settle the stew. I have to settle something today.

"Off button? OFF BUTTON — I knew I'd forgotten something!"

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Power Hack Saw Builder Fastens blade guides with FLEXLOC self-locking nuts. Eight of these one-piece, all-metal locknuts are used in this assembly. And they won't work loose, regardless of vibration.

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Use FLEXLOCs anywhere:

ON ROUGH BOLTS. FLEXLOCS smooth out bolt threads without damaging their own threads.

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THE ENGINEER'S Library

Recent Books

Principles of Machine Design. *By Samuel J. Berard, professor emeritus of mechanical engineering, Brown University; Everett O. Waters, professor of mechanical engineering, and Charles W. Phelps, assistant professor of mechanical engineering, Yale University; 544 pages, 6 by 9 inches, clothbound; published by the Ronald Press Co., New York; available from* MACHINE DESIGN, *$7.50 postpaid.*

Aim of this textbook is to develop rational and consistent methods of design, as applied to more common mechanical elements of machine construction. Relative importance of theory and conventional practice, and exercise of sound judgment in proportioning of parts are emphasized.

Part 1 is devoted to fundamentals, engineering materials and principles of theoretical design. In Part 2, on fasteners and fastening methods, emphasis is given to the Unified and American Standard for screw threads and particular attention is given to welding. Parts 3 and 4 are devoted to power-transmission equipment, including shafting, couplings, clutches, bearings, belts, chains and gears. Part 5 covers cams, linkages, springs, brakes, curved beams, hydraulic control equipment, and other mechanisms and elements.

•

Human Engineering Guide for Equipment Designers. *By Wesley E. Woodson, U. S. Navy Electronics Lab., San Diego; 276 pages, 8 by 10½ inches, paperbound; published by University of California Press, Berkeley, Calif.; available from* MACHINE DESIGN, *$3.50 postpaid.*

This book is intended to aid designers in considering human factors in developing man-operated equipment. It provides a central source for information about the

The Engineer's Library

human operator and points up the relative importance of variables. Solutions are indicated for typical design problems. Subjects covered in five chapters include design of equipment and workspace, vision, auditory sense, body measurement and other factors, such as body sensitivity, movement, control and orientation.

•

Linearized Theory of Steady High-Speed Flow. *By G. N. Ward, professor of mathematics, College of Aeronautics, Cranfield, England; 259 pages, 5½ by 8½ inches, clothbound; published by Cambridge University Press, New York; available from* MACHINE DESIGN, $6.00 *postpaid.*

Dealing with compressible fluids, the first part of this monograph gives the derivation and interpretation of linear equations for steady motion, solution of these equations, discussion of boundary conditions and aerodynamic forces, and deduction of results. The remainder treats various specific boundary value problems and methods developed for their solution.

This book is intended primarily for applied mathematicians and designers who, in working on problems of high-speed flow, require a concise account of important aspects of the linearized theory.

•

Sonics. *By Theodor F. Hueter, research associate in physics, and Richard H. Bolt, professor of acoustics, Massachusetts Institute of Technology; 468 pages, 5¾ by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, $10.00 *postpaid.*

Principles and practices of sonics, covering the entire frequency range from audible sounds to ultrasonics, are covered in this book. Common principles are presented in general form and then applied in many special ways to the design of sonic techniques for a particular medium or frequency

(*Continued on Page* 322)

THE ANSWERS

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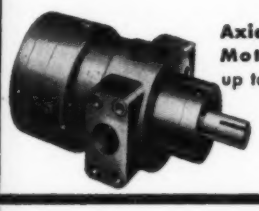

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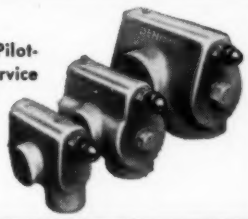

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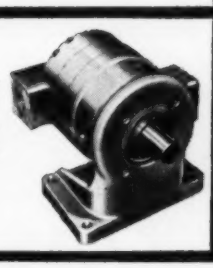

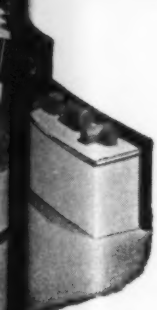

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DENISON Hydr OIL ics

The Engineer's Library

(*Continued from Page* 319)

range.

Following an introductory chapter, relevant fundamentals of vibration and sound are given in Chapters 2 and 3. General aspects of transducers for sound generation and reception are presented in Chapters 4 and 5. Applications are divided into two branches: sonic processing, Chapters 6 and 7; and sonic analysis, Chapter 8.

Major emphasis is on techniques and instrumentation for accomplishing actual tasks in industry. Typical examples are selected to illustrate operating principles and suggest further uses. Included also are critical comments on limitations and economic aspects of sonics. Wherever possible a discussion is concluded with simplified engineering formulas and practical instructions for their application.

New Standards

ASTM Standards on Petroleum Products and Lubricants, 1954. *984 pages, 6 by 9 inches, paper or cloth-bound; available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.,* $6.00 *per copy paperbound, or* $6.65 *cloth-bound.* ($4.50 *or* $5.15, *respectively, for ASTM members.*)

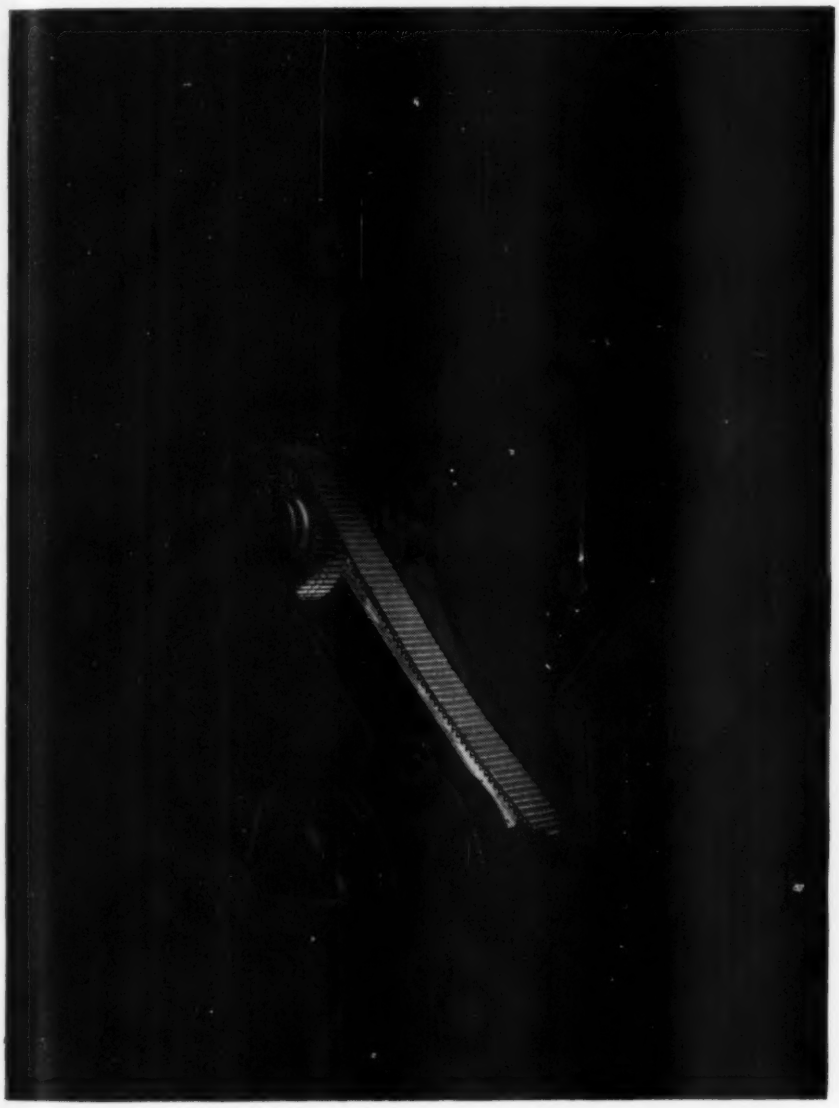
This annual publication is a compilation of ASTM standard and tentative specifications, tests and definitions covering petroleum products and lubricants. It does not include methods of test for knock rating of engine fuels and several standards for measuring and sampling petroleum, which appear in other ASTM publications.

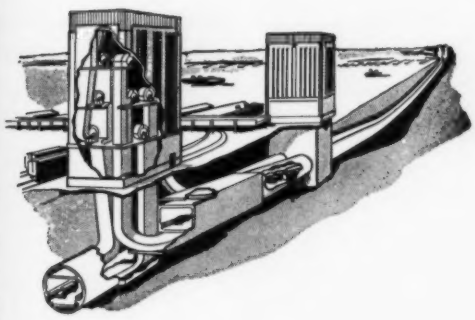
•

Letter Symbols for Aeronautical Sciences. *ASA Y10.7-1954;* 30 *pages,* 8½ *by* 11 *inches, paperbound; available from American Society of Mechanical Engineers,* 29 *W.* 39*th St., New York* 18, *N. Y.,* $1.25 *per copy.*

Listings of letter symbols for aeronautical engineering are presented in this standard for primary and secondary concepts, the latter consisting of subscripts and

Morse equipment helps ventilate Lincoln Tunnel for 18 years — without replacements!





Lincoln Tunnel: Operated by The Port of New York Authority, it is a major artery connecting mid-Manhattan with New Jersey.

Here, 26 blowers and 30 exhaust fans circulate millions of cubic feet of air per minute through the tunnel. Because these ventilation units provide a complete change of air in the tunnel every 1½ minutes, they require dependable power transmission equipment. It is significant that Morse power transmission equipment is used in many of these units.

Shown at left is a typical blower unit, which employs a 6 in. Morse Silent Chain operating at 7½ hp at 445 rpm or 60 hp and 884 rpm. This unit, as well as the others in the ventilation system, has been operating for 18 years with little maintenance, and no breakdowns.

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superscripts. An appendix gives recommended designations for systems of axes, angular relationships and related quantities.

•

Machine Pins. *ASA B5.20-1954; 10 pages, 8½ by 11 inches, paperbound; available from American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y., $1.00 per copy*

This standard lists dimensions for dowel, straight, taper, clevis and cotter pins. An appendix covers drilling specifications for taper pins. Diameters of most pins listed are 1 inch and under.

•

Socket Head Cap Screws and Socket Set Screws. *ASA B18.3-1954; 19 pages, 8½ by 11 inches, paperbound; available from American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y., $1.00 per copy*

This standard contains tables of dimensions for hexagonal and fluted socket-head cap screws, shoulder screws (stripper bolts), socket set screws and socket-screw keys. An appendix contains formulas for dimensions.

Association Publications

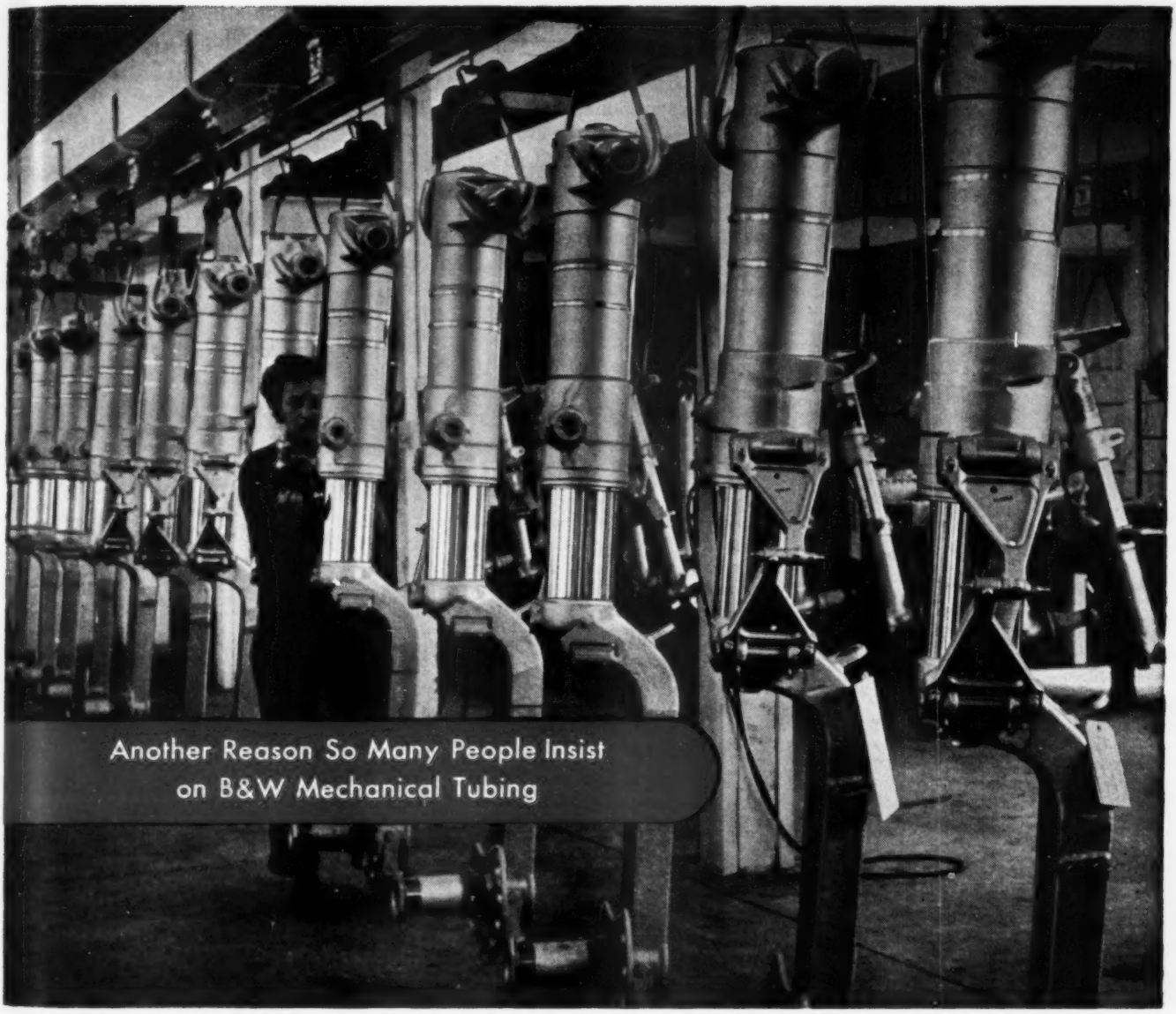
Cold Rolled Carbon Steel Strip. *27 pages, 8½ by 11 inches, paperbound; available from American Iron and Steel Institute, 350 Fifth Ave., New York 1, N. Y.*

This revised section of the AISI Steel Products Manual discusses metallurgical aspects, manufacturing practices, quality descriptions and chemical requirements of cold-rolled carbon steel strip.

•

Proceedings of the National Conference on Industrial Hydraulics, Volume 8, 1954. *294 pages, 6 by 9 inches, paperbound; available from National Conference on Industrial Hydraulics, Technology Center, Illinois Institute of Technology, Chicago 16, Ill., $4.50 per copy.*

This volume contains illustra-



BUILDING THE LITTLE CLICK THAT SAYS ALL IS WELL

Every pilot who ever flew an airplane knows that the world's most reassuring sound is the little click that says "landing gear down *and locked.*" It's important because it means a safe landing. It insures coming in on your wheels instead of your belly.

Providing that reassurance is the job of Menasco Manufacturing Company, which specializes in the design and manufacture of landing gear components for the country's leading airframe manufacturers. Critical landing gear design and construction factors include weight conservation, space limitation, faster and more economical production methods, and the increasing takeoff and landing speeds of modern aircraft.

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tions and text of the 19 papers and panel discussions presented at the tenth meeting of the National Conference on Industrial Hydraulics, sponsored by the Graduate School and Armour Research Foundation of Illinois Institute of Technology, in October, 1954. After a general session, various technical sessions covered machine tools, pumps, heat dissipation, presses, lift trucks, pneumatic controls, hydraulic fluids, automotive applications and aircraft controls.

Manufacturers' Publications

Holes, Contours and Surfaces. *By Richard F. Moore and Frederick C. Victory; 422 pages, 7 by 10 inches, clothbound; published by and available from Moore Special Tool Company, Bridgeport, Conn., $7.50 per copy (or $5.00 within the metalworking industry in the U. S. A., $6.00 elsewhere).*

Purpose of this book is to discuss methods and equipment which provide accurate location of holes, contours and surfaces. These factors are discussed in chapters covering location; improvised equipment and methods; accuracy; engineered standards; co-ordinate locating system; jig boring principles, applications and practices; jig grinding principles and applications; jig grinding holes and contours; linear form grinding principles, applications and practices; inspection methods; and precision.

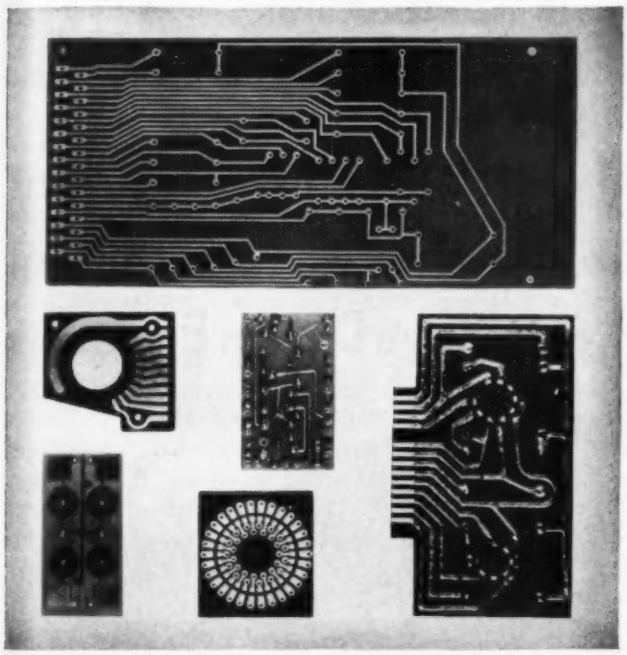
An added feature is the 184-page section of Woodworth Circular Tables for converting holes on circles to rectangular co-ordinates.

•

Metallic Rectifier Manual. *168 pages, 6 by 9 inches, ringbound, paper-covered; available from Bradley Laboratories Inc., 168 Columbus Ave., New Haven 11, Conn., $2.00 per copy.*

This illustrated handbook on selenium and copper-oxide rectifiers has been prepared primarily for design and development engineers. It deals with rectifier types, designs, circuitry, characteristics and applications.

For the most dependable printed circuits, you need the high bond strength, workability, heat-resistance of C-D-F DILECTO® METAL-CLAD LAMINATES



Printed circuits based on C-D-F materials are being used with great success in military electronic equipment, commercial television and radio sets, telephone switchboards—even sub-miniature radiosonde equipment and hearing aids.

Photos courtesy of Photocircuits, Inc., Glen Cove, N. Y.

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TYPICAL PROPERTY VALUES

	Copper-Clad PHENOLIC (Grade XXXP-26)	Copper-Clad PHENOLIC (Grade XXXP-24)	Copper-Clad EPOXY (Grade GB-116E)	Copper-Clad EPOXY (Grade GB-181E)	Copper-Clad TEFLON* (Grade GB-116T)
BOND STRENGTH—0.0014" foil (Lbs. reqd. to separate 1" width of foil from laminate)	5 to 8	5 to 8	8 to 12	8 to 12	5 to 8
MAXIMUM CONTINUOUS OPERATING TEMP. (Deg. C.)	120	120	150	150	200
DIELECTRIC STRENGTH (Maximum voltage per mil.)	800	800	700	650	700
INSULATION RESISTANCE (Megohms) 96 hrs. at 35°C. & 90¾ RH	50,000	50,000	30,000	20,000	Over 10^6 megohms
DIELECTRIC CONSTANT 10^6 Cycles	4.20	4.20	4.90	4.95	2.85
DISSIPATION FACTOR 10^6 Cycles	0.026	0.026	0.019	0.018	0.0006
ARC-RESISTANCE (Seconds)	10	10	60	80	180
TENSILE STRENGTH (psi.)	16,000 x 13,000	14,000 x 11,000	46,000 x 42,000	48,000 x 44,000	23,000 x 21,000
FLEXURAL STRENGTH (psi.)	21,000 x 18,000	19,000 x 16,000	60,000 x 55,000	75,000 x 65,000	13,000 x 11,000
IZOD IMPACT STRENGTH edgewise (ft. lbs. per inch of notch)	0.40 x 0.35	0.40 x 0.35	6.5 x 6.0	13.5 x 11.5	6.0 x 5.0
COMPRESSIVE STRENGTH flatwise (psi.)	28,000	27,000	60,000	62,000	20,000
BASE MATERIAL OF LAMINATE	Cotton rag paper	Cotton rag paper	Fine-weave, medium-weight glass cloth	Medium-weave, medium-weight glass cloth	Fine-weave, medium-weight glass cloth
COLOR OF UNCLAD LAMINATE	Natural greenish	Natural Brown	Natural	Natural	Natural

All these standard grades are available with 0.0014", 0.0028", 0.0042", or thicker electrolytic or rolled copper foil on one or both surfaces. Other metal foils and other resin-and-base combinations can be supplied on special order.

*duPont Trademark

CDF Continental-Diamond Fibre

CONTINENTAL-DIAMOND FIBRE DIVISION OF THE BUDD COMPANY, INC.

NEWARK 23, DELAWARE

NOTEWORTHY

Patents

Slip Coupling

Overload is prevented in light-duty machine drives with a slip clutch that utilizes a square cam as the driving element. Four lugs are mounted radially and slightly off center with respect to the cam. One lug is in contact with each flat outer face of the driving cam and the lugs are held in position by a garter spring. In operation, driving force is transmitted from the cam through the lugs to a cage, surrounding the clutch assembly, which serves as the output member. The outer periphery of the cage may be used as a pulley for power takeoff. When overloaded, the clutch slips, producing a loud noise to warn the operator of the overload. When load is reduced to a safe level, the clutch resumes quiet operation. Load limit can be varied by changing the tension of the garter spring. *Patent* 2,692,486 *assigned to Underwood Corp. by Walter A. Anderson.*

Mercury Switch

Electrical switching without contacts is accomplished by a switch employing two mercury-filled chambers connected by a capillary tube. Pressure inside one of the chambers is varied by a bellows integral with the chamber. As the pressure is increased within that chamber, mercury is forced into the capillary tube joining mercury in the second chamber to complete the electrical circuit. As the pressure is decreased, the mercury in the capillary tube is separated, breaking the circuit. Wire terminals are provided in each of the mercury chambers. Any arcing that may occur is confined within the capillary tube, making the device useful for switching in explosive atmospheres. *Patent* 2,695,938 *assigned to Northrop Aircraft Inc. by Robert D. Hancock.*

Miniature Air Bearing

A film of air is utilized to reduce friction between closely-fitted spherical instrument bearing surfaces. In this design the air film is supplied through a series of air inlets which serve as pressure pockets. These pockets are symmetrically arranged around the inside of a retaining cup so that instability is avoided. Specially designed orifices prevent torque being exerted upon the rotating spherical bearing surface by the air jet. A suction pocket is also provided to prevent the sphere from bouncing out of the supporting cup. Designed primarily for use with

(*Continued on Page* 332)

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2. Iron Pump Gear
3. Flanged Bronze Bushing
4. Iron Shifter Fork Lever
5. Bronze Pump Rotor
6. Nickel Silver Thrust Washer
7. Bronze Self Aligning Bearing

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

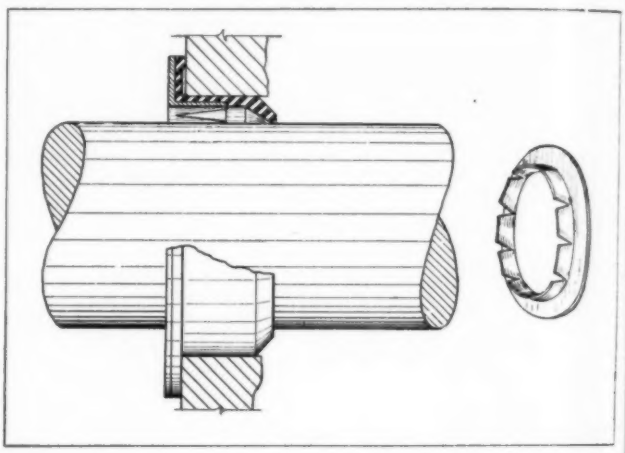
Noteworthy Patents

(*Continued from Page* 329)

instruments such as gyro-compasses, the device can also be adapted to other similar light-duty precision applications. *Patent* 2,695,198 *assigned to Sperry Corp. by R. G. Brugger.*

Rotating Shaft Seal

Fluidtight sealing is maintained under conditions of eccentric shaft rotation by backing up a rubber seal with a metal ring. Metal fingers of the supporting ring hold the seal in position and maintain sealing pressure. The ring also prevents leakage by maintaining compression if the rubber takes a set. The seal is also suitable for application on irregular surfaces. *Patent* 2,692,785 *assigned to National Motor Bearing Co. by N. S. Reynolds.*



Ring-Oiled Sleeve Bearing

Lubricant is supplied to a sleeve bearing by a method that eliminates the need for internal spiral or longitudinal grooves in the inner bearing surface. Oil is picked up by an oil ring, brought to the top of the bearing to the ring slot and wiped off into depressions formed in the top outer surface of the sleeve. From these depressions, the lubricant flows through slots into internal grooves cut in the ends of the bearing. Since these circumferential oil grooves are considerably shorter in length than conventional designs, loading of the bearing may be increased considerably. *Patent* 2,692,172 *assigned to Ideal Electric and Mfg. Co. by S. M. Weaver.*

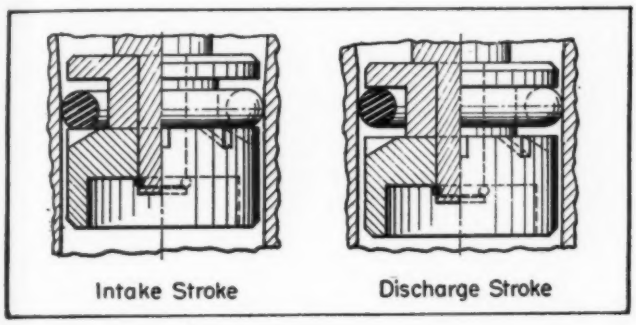
Antibacklash Ball-Bearing Screw

Backlash normally encountered in a ball-bearing screw and nut assembly can be eliminated by employing a nut of adjustable, elliptical cross section. Clearance between the screw and the nut at the minor axis of the ellipse is held to a minimum to eliminate backlash. Clearance between the components at the major axis is considerably greater to reduce resistance to the passage of the balls. Adjustment of the clearances is accomplished by splitting the nut and adjusting the gap by means of screws. Holding the area of close clearance to a minimum permits

the unit to be adapted to high-speed operation. *Patent* 2,694,942 *assigned to Norden Laboratories Corp. by J. S. Hellen.*

Expansible-Chamber Fluid Pump

An O-ring made of Teflon or similar material seals the reciprocating piston of this fluid pump. Mounted in an oversize groove in the piston, the ring acts to prevent or permit the flow of fluid



past the piston, depending on the direction of piston travel. On intake, fluid flows into the inside diameter of the ring and out through radial grooves in the piston. On discharge, the ring seals the fluid opening to prevent leakage of fluid back into the fluid reservoir. *Patent* 2,689,533 *assigned to Carter Carburetor Corp. by G. R. Ericson.*

High-Speed Pulley

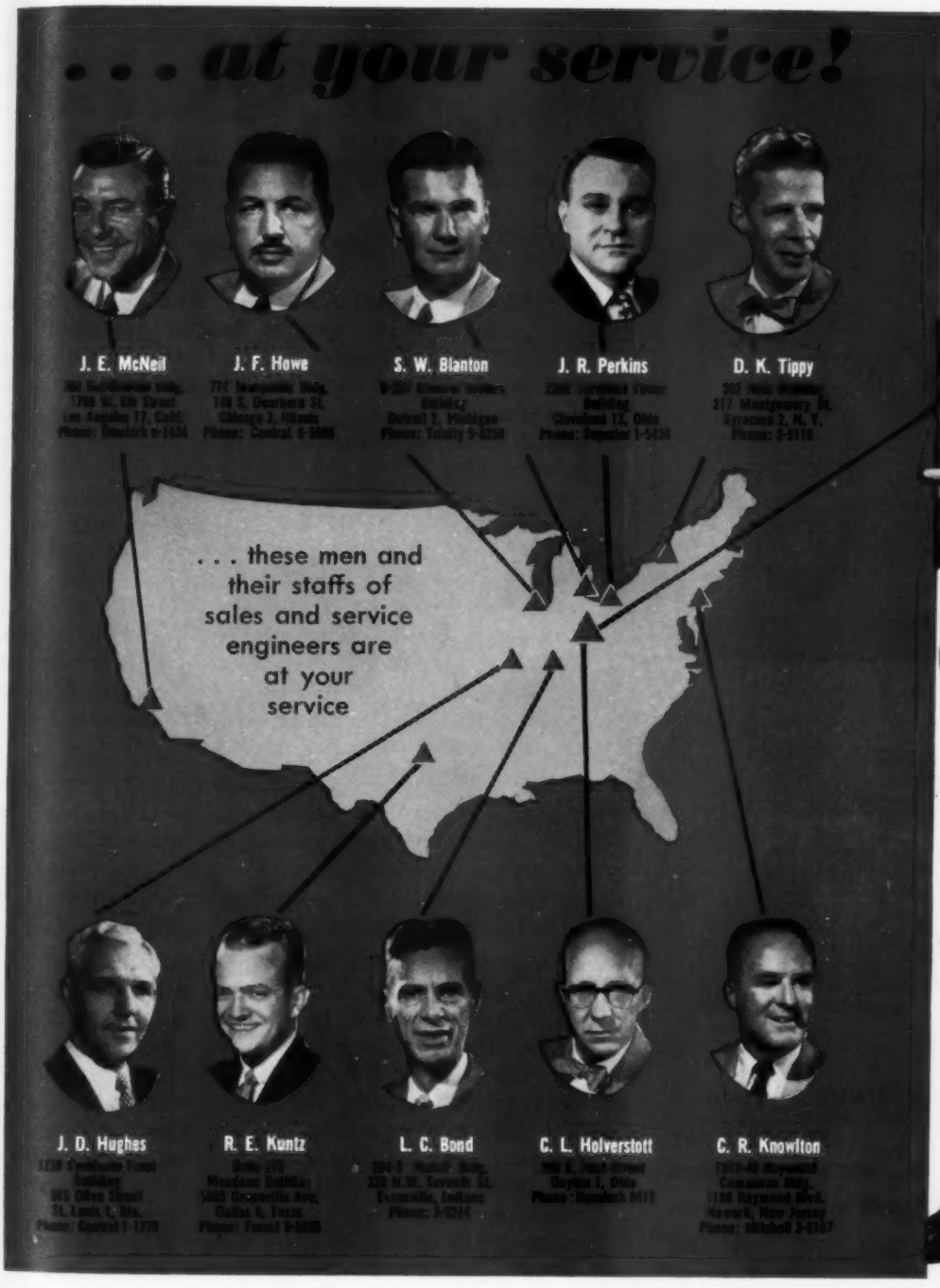
Automatic centering of high-speed belts is accomplished by a two-piece pulley in which the crown profile varies according to belt tension. Each half of the pulley has the shape of a frustum of a cone with the large diameters at the center. Tension bolts hold the two halves together, but clearances are designed to permit deflection under load. The device is suitable for use with flat belts traveling at speeds up to about 4000 fpm. *Patent* 2,692,773 *assigned to U. S. Steel Corp. by E. T. Lorig.*

Centrifugal Clutch

Steel balls between two cam surfaces control the operation of a centrifugal clutch. Under centrifugal force, the balls move outward to drive friction-V-shaped surfaces into engagement. A variation between engaging and disengaging speeds of the clutch may be obtained by modifying the design of the cam surfaces. Ratio between engaging and disengaging speeds may also be varied by changing the weight and number of the balls and the tension of a retaining spring holding the cam surfaces together. *Patent* 2,690,826 *assigned to Bendix Aviation Corp. by R. W. Stelzel.*

Correction: Radial-Flow Fans

Efficiencies in *Figs.* 15 through 18 in the article, "Radial-Flow Fans," July, Page 165, should be one-half of the values shown.



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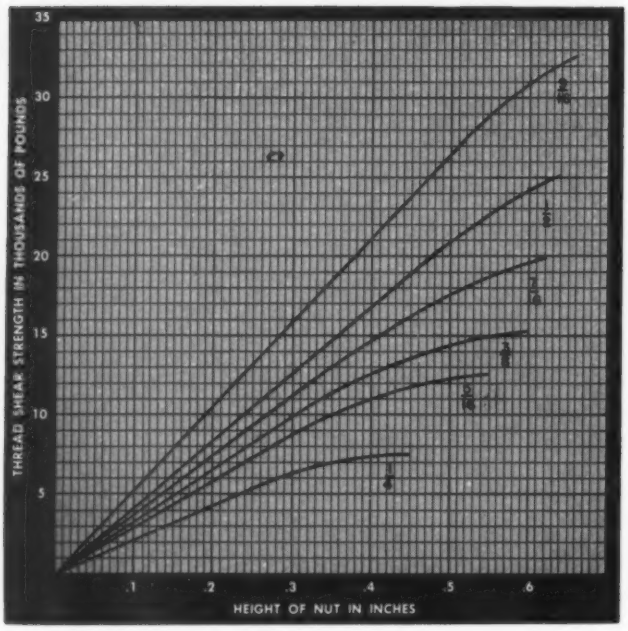


Figure 2

New Machines

Metalworking

Drilling Machines: New 16-in. sliding-head bench, floor and multiple spindle drilling machines are built with integral motor and controls. Geared power feed is available to facilitate drilling and to increase production. Any one of four rates of feed are engaged through a positive jaw clutch. The entire power feed mechanism is built in and housed in the head. A direct reading depth dial with positive stop is provided. When the drill is equipped with power feed, the dial may be set to disengage feed automatically. The spindle is full-floating. A V-belt drive transmits motor power directly to the spindle, and a tilting motor bracket is provided to facilitate spindle speed changes. Drills are rated at 1 in. in cast iron with a 1 hp, 1800 rpm motor. A No. 2 Morse taper spindle is standard. *Cincinnati Lathe and Tool Co., Cincinnati, O.*

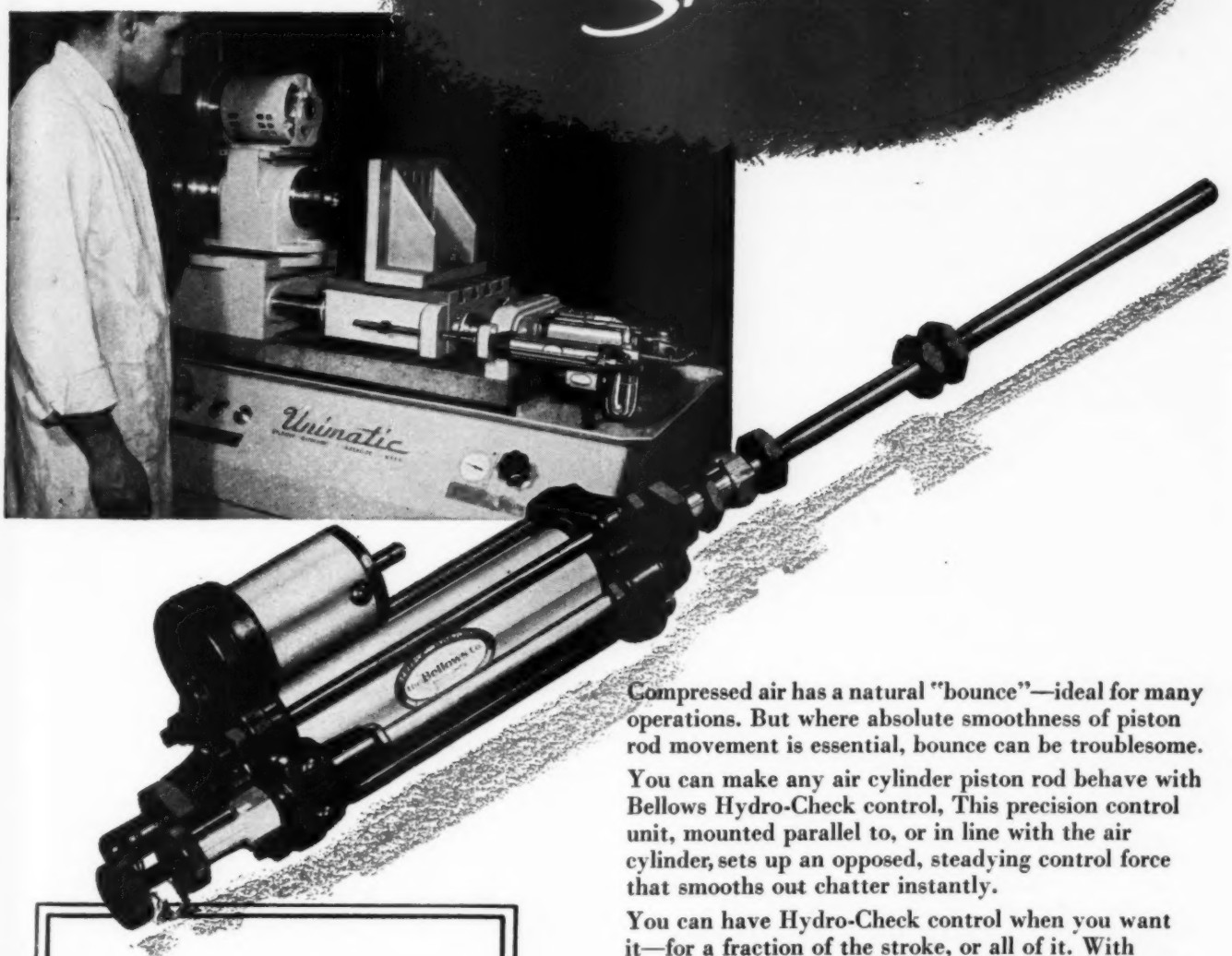
Noiseless Riveter: A new motor-driven rivet spinner forms rivet heads noiselessly. It is available in both floor and bench models, for either foot or air operation. Rivet capacity is up to $\frac{5}{16}$-in. diameter. Spindle travel is ¾-in., adjustable downward. *High Speed Hammer Co. Inc., Rochester, N. Y.*

Gear Shaver: New Red Ring rotary machine finishes external spur and helical gears. Designated model GCU-18-in., it is available in three different types. One shaves gears by the diagonal process. The other two shave gears by either the diagonal or conventional process and have automatic differential upfeed mechanisms. One of these models also has provision for crown shaving operations. Gears from 2¼ to 18 in. pitch diameter having 4 to 16 diametral pitch teeth can be processed. The table has a maximum stroke of 5 in. A 3-hp motor drives the cutter, and a ½-hp motor powers the table drive. Pushbutton controls are built into the upper column portion of the machine. *National Broach & Machine Co., Detroit, Mich.*

Roll Formers: Available in a wide range of power and hand-operated models, a new line of slip roll forming machines has pinch type rolls which produce commercially true cylinders virtually free from flat spots. Two rolls feed the materials, and the third, located at the rear of the machine, deflects the sheet to produce the curvature. The upper feed roll, around which the sheet is formed, swings open at one end for removal of completed cylinders. Machines form metal sheets up to 120 in. long in thicknesses up to ¼-in. mild steel. They are built in heavy, medium and light capacities with 6, 4, 3, 2, 1½ and 1-in. rolls. *Niagara Machine & Tool Works, Buffalo, N. Y.*

Portable Spot Welder: Preset timing intervals, ranging from 1/60 to 1 second, assure uniform welds

how to give any air cylinder... *Hydraulic Smoothness*



Compressed air has a natural "bounce"—ideal for many operations. But where absolute smoothness of piston rod movement is essential, bounce can be troublesome.

You can make any air cylinder piston rod behave with Bellows Hydro-Check control, This precision control unit, mounted parallel to, or in line with the air cylinder, sets up an opposed, steadying control force that smooths out chatter instantly.

You can have Hydro-Check control when you want it—for a fraction of the stroke, or all of it. With certain models of Hydro-Checks you can have "Skip"—or intermittent checking action; or you can stop an air cylinder piston at any point in its travel for a predetermined time and then resume traverse. Hydraulic control can be on either advance or retract strokes or on both.

If you use air cylinders in precision operations, you'll want to know more about Bellows Hydro-Checks — precision hydraulic control for air cylinder power. Write for Bulletin HC-601 Address: The Bellows Co. Dept. MD955 Akron 9, Ohio. In Canada: Bellows Pneumatic Devices of Canada, Ltd. 14 Advance Rd., Toronto, Ont.

The Bellows Co.

AKRON 9, OHIO

1223-A

New Machines

by a new portable spot welder. Built-in electronic thyratron type timing control operates a solenoid contactor. Electrode pressure up to 1000 lb can be developed. Over 17,000 amps are delivered at point of weld. Throat depth of the machine is 6 in., with opening variable from 3 to 11 in. Steel and other metals of 3/16-in. combined thickness can be welded. Housed in aluminum, the welder weighs 55 lb. A stand is available for mounting the welder for use as a foot-operated floor model. *Ross Machine Tool Co., Chicago Ridge, Ill.*

Straightening Machine: Heavy-duty detwister re-straightens large aluminum alloy extrusions which have been warped and twisted by heat treating. It aligns irregular sections, which can be contained within a 24-in. diameter circle, in lengths up to 85 ft. Maximum torque is 3,000,000 lb-in. at 2.5 rpm. In operation, a workpiece is lowered from the top into position between the headstock and tailstock. The tailstock is motor-driven along the bed to accommodate various lengths of extruded work. Distance between the heads can be varied from 3 to 20 ft. Headstock rotation is infinitely variable from 0 to 3 rpm. Work is clamped in place by T-slotted jaw carriers operated by motors in both headstock and tailstock. *Sutton Engineering Co., Pittsburgh, Pa.*

Power Plant Equipment

Air Compressor: Model 100 portable air compressor delivers up to 100 psi pressure and 3.5 cfm of free air. No tank or safety valve is required. Sealed ball bearings are used throughout, and no lubrication is needed. Compressor is complete with built-in intake filter and has a ⅓-hp motor equipped with capacitor and overload protector. Unit is 13 in. long, 10 in. high and weighs 40 lb. *Modernair Corp., San Leandro, Calif.*

Electric Plants: Two generators, designated model 25EC (25 kw) and 35ED (35 kw), are powered by short-stroke, high-compression Ford industrial engines. These units are revolving field generators and have ±2 per cent voltage regulation and three-cycle frequency regulation. Design incorporates self-aligning semiflexible drive disk, dripproof construction, constant pressure brush springs, double-sealed prelubricated ball bearings and automatic voltage regulators. All standard voltages are available for 60-cycle, single and three-phase models. Both generators are available either fully housed or unhoused. *D. W. Onan & Sons Inc., Minneapolis, Minn.*

Processing

Plating Machine: Platocrat is designed for automatic production plating. It has a replaceable plating tank which permits changing from cadmium to zinc quickly, pulling one tank aside and replacing it with another. Plating tank is electrically isolated from the rest of the mechanism to eliminate the possibility of stray currents. Plating cycle provides for as many as seven stations in both the preplating and post-plating operations. Racks are 12 x 6 x 30 in. The

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The greater purity and uniformity of vacuum-melted metals means substantially higher production yields in your plant . . . fewer inspection rejects. In ball bearing manufacture, for example, inspection loss was cut from 50% to 3% when vacuum-melted metals were used.

That's because vacuum-melted metals are free of nonmetallic inclusions . . . better physically . . . closer to their theoretical limits of performance. For in vacuum melting, gaseous impurities are literally sucked from the molten metal. Composition limits are more closely held . . . fabrication characteristics improved.

Vacuum Metals Corporation, pioneer in development and leading producer of vacuum-melted metals, now has them available in tool, high-speed, stainless and alloy steels — in most sizes and grades — as well as special ferrous and nonferrous alloys. If you have a metals problem that vacuum-melted alloys might solve, please describe it in as much detail as possible. Write *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, N. Y.*

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Jointly owned by Crucible Steel Company of America and National Research Corporation

New Machines

machine is hydraulically powered. An automatic hydraulic loader is available as optional equipment. *Wagner Brothers Inc., Detroit, Mich.*

Heat-Treating Units: TFC series heat-treating units have multiple cooling zones for air cooling of work under protective atmospheres. Carburizing, carbonitriding, normalizing, annealing, stress relieving and brazing operations are performed. Three units have capacities of 400, 500 and 900 lb per hour at 1500 F; maximum weight per charge is 600, 800 and 1400 lb, respectively. Standard operating temperature is 1850 F. Designs are of straight-through processing type; after heating, the work is transferred automatically to the cooling zones by the Cold-Chain transfer system, wherein the hot portion of the chain is never under stress. Automatic loading is standard on the largest model, optional on the other two sizes. Automatic unloading is optional on all models. *Ipsen Industries Inc., Rockford, Ill.*

Descaler: Model ES-537 Rotoblast machine descales hot rolled sheets, plates and coils, cleaning both sides of the material simultaneously at a rate up to 360 sq ft per side per minute. Abrasive blasts from top and bottom hit the sheet at the same point, minimizing the tendency to warp. The machine is equipped with eight wheels which are capable of throwing 480,000 lb of abrasive per hour. The wheels are set at a 78-deg angle and are powered by 40-hp, 1800-rpm motors. Machine is approximately 24 ft high, 18 ft wide and 22 ft long. *Pangborn Corp., Hagerstown, Md.*

Testing and Inspection

Portable Balancer: Particularly applicable to large parts, a new self-contained portable balancer provides a means for balancing parts which cannot be handled economically in a precision type balancing machine. Complete vibration analysis, as well as dynamic balancing, can be done easily and accurately. Machine is capable of balancing parts at speeds of 250 rpm. Housed in a lightweight carrying case, the equipment consists of one inertia type pickup, a stroboscope light, an amplifier with range switch, and all necessary cables. *Tinius Olsen Testing Machine Co., Willow Grove, Pa.*

Leak Detector: Type M-1 mass spectrometer leak detector is designed for testing and inspecting vacuum and pressure systems. It detects a leak rate of 5×10^{-10} standard cu cm of air per second entering an evacuated system under atmospheric pressure. The device can be used selectively to locate a specific leak in the presence of other leaks without loss of sensitivity. Twenty sensitivity ranges are provided by means of attenuating factors of 1, 3, 10, 50 and 150, and by four levels of emission current, making possible the location of leaks of different sizes. The vacuum system is composed of stainless-steel mechanical rough pump, oil diffusion pump and liquid nitrogen dual cold trap. All components can be disassembled easily for cleaning and replacement of parts. *General Electric Co., Instrument Dept., Lynn, Mass.*